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Johnsen, Thomas Erik

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ON THE MANAGEMENT OF COLLABORATIVE INNOVATION IN NETWORKS

Submitted by
THOMAS ERIK JOHNSEN
For the degree of PhD of the University of Bath

2004

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THESIS ABSTRACT
Thomas Johnsen
University of Bath School of Management

Research on the management of collaborative innovation has, to date, largely concentrated on analysing relationships between two companies or, more recently, within coalitions of companies. There has been a paucity of research on how innovating companies deploy the resources and technologies available within their wider industrial networks whilst at the same time coping with the problem of loss of control of knowledge through the very same networks. This is the subject of the present thesis.

A conceptual framework is developed, which is structured around a set of activities that companies apply during product innovation to manage collaborative innovation. These activities are: - uniting, mobilising, synchronising, communicating, problem solving, exchanging human resources and timing. The conceptual framework provides an analytical structure for examining the positive, enabling, effects of networks on the management of collaboration activities, and the negative, constraining, effects. The framework differentiates a variety of ways in which these network effect may manifest themselves during product innovation projects.

The empirical data collection comprises an exploratory mini-survey involving five interviews with companies in the automotive and pharmaceutical sectors, and four in-depth case studies involving 46 interviews with a range of companies in the automotive and telecommunications sectors.[1] The findings from the thesis provide indications that more than any other activities, uniting and communicating appear to be affected by the surrounding network in which they take place, both enabling and constraining the management of these two activities. Hence, this study contributes to the debate on the different forms of network effect on the innovation management process, and explores how companies can cope with and exploit these paradoxical effects.

[1] The number 46 includes three interviews from an abandoned case.

ACKNOWLEDGEMENTS

This thesis is the culmination of six years' doctoral research. The first half of the study was undertaken concurrently with my position as a Research Officer in the Centre for Research in Strategic Purchasing and Supply (CRiSPS), working on a project on Inter-Organisational Networking (Project ION). During the second half of the study I have moved into lecturing, initially focusing on marketing at Bournemouth University. Since June 2002 my lecturing has focused on purchasing and supply. This means that during the course of the study I have not only moved office several times, but I have also moved – and sought to balance - between what has traditionally been seen as 'opposite' subject areas, namely marketing and purchasing/supply. My hope is that something fruitful has come out of this balancing act. It has by no means been easy and indeed at times frustrating: as such my study has in many ways resembled the process which it has sought to describe: *innovation*.

Without doubt working in different research communities has exposed me to many different views and therefore by implication to many different people. My beliefs, assumptions and knowledge have been borne out of interaction with these people, some pulling me in one direction, others in another direction. Without these people this thesis would not have materialised. I cannot hope to thank all of these people here but will attempt to mention the most obvious.

First and foremost my thanks go to Professor David Ford whose supervision has provided a constant source of inspiration: thanks for putting up with me and my strange ideas for six years! My colleagues at CRiSPS have provided much input over the years. Here my thanks first of all go to Professors Christine Harland and Richard Lamming for having shared their knowledge and ideas with me and for funding for my interviews. Other colleagues at CRiSPS have also provided invaluable help, including Doctors Louise Knight, Jurong Zheng, Nigel Caldwell, Helen Walker, and Wendy Philips. Katy McKen and Adele Draper have both provided much administrative assistance which is greatly appreciated. Thanks are also due to academic colleagues from across the world but especially: Doctors Thomas Ritter and Debbie Harrison. In addition, the 'IMP1b' team helped to shape, and provided feedback on, many ideas: Professors Peter Naudé (who has also been my internal examiner), Kristian Möller, Jan-Åke Törnroos, Peter

Turnbull, David Wilson, Achim Walter, Robert Salle, and Doctors Arto Rajala, and Sheena Leek. Other colleagues including Professors Lars-Erik Gadde, John Bessant, Nick Oliver, Suzanne Hertz, Doctor George Tsekouras, Doctor Finn Wynstra and Mickey Howard have also provided feedback and friendship at various stages. Professor Håkan Håkansson's work not only provided a wealth of inspiration for my work, but he also served as the external examiner on the thesis: for this I am very grateful.

The industrial contacts that I have gained as part of the Ph.D. need to remain confidential. Thanks are due to everybody who was interviewed as part of the study.

Finally, my thanks go to my family: many dinners have been completely hijacked by discussions related to my study. Last but not least, I would like to thank my wife and co-researcher Rhona without whose intellectual challenge, support and love this thesis would not have been possible.

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Overview of Part One

The purpose of Chapter One is to provide an overview of the context of the thesis. The chapter will introduce the relevance and contribution of the study, define the subject of inquiry - collaborative innovation in industrial networks - and the research problem, and explain the research aim and objectives. An overview of the research approach and methodology is provided and the structure of the thesis is outlined.

Chapters Two and Three explain the academic context of the inquiry through a critical review of the existing research on innovation and customer-supplier relationships in industrial networks. Based on this literature review, Chapter Four presents the conceptual framework, which has been developed from the literature review and undergone iterations following exploratory empirical findings. Thus, what is presented in Chapter Four represents the final version of the framework.

CHAPTER ONE: INTRODUCTION TO THE THESIS

1.0. Introduction

This thesis is concerned with some of the critical issues facing companies when they are involved in collaboration with others in developing and implementing innovations. These issues centre on the simultaneous opportunities and problems in collaborative innovation in industrial networks. On the one hand, inter-company collaboration can provide the opportunity for companies to capitalise on the technologies and skills of other companies in the surrounding network. However, on the other hand, such collaboration can lead to problems in retaining control over the company's own resources and technologies. This paradox is the subject of inquiry of the thesis.

Chapter One sets out the context of the thesis, thus introducing the relevance and contribution of the study. The chapter defines the basic problem, which drives the study, and explains the research aim and objectives. A brief note is made to provide an overview of the research approach and methodology. The chapter concludes by outlining the structure of the thesis.

1.1. The Subject and Context of Inquiry

A substantial body of research has reported a 'strong upsurge' of various forms of inter-organisational collaborative ventures for innovation (e.g. Freeman, 1991; Hagedoorn, 1995; Hagedoorn and Schakenraad, 1990). The concept of collaborative innovation also seems to be receiving increasing attention amongst academic scholars. Researchers have examined vertical collaboration with customers (e.g. Von Hippel, 1988; Lundvall, 1986; Voss, 1985), suppliers (e.g. Clark, 1989; Lamming, 1993; Takeuchi and Nonaka, 1986; Womack *et al*, 1990; Wynstra, 1998; Bideault and Butler, 1995), and horizontal collaboration with universities, research associations, or even competitors (e.g. Hamel *et al*, 1989; Hagedoorn, 1993, 1995; Kotabe and Swan, 1995).[2] The concepts of 'networks of innovators' or 'innovation networks' have also emerged (e.g. Freeman, 1991;

[2] Collaboration may be vertical i.e. part of an on-going relationship within the value or supply chain, or horizontal i.e. across value/supply chains: competitive or complementary (see also Håkansson, 1987; Easton and Araujo, 1992).

DeBresson and Amesse, 1991; Imai and Baba, 1989). The reasons for the apparent recognition of many companies across industries to engage in different modes of collaboration with a myriad of external parties are multiple. The increasing intensity of global competition means that time and speed are now regarded as key competitive factors (Stalk and Hout, 1990). Consequently, there is a need to reduce product development time and cost whilst improving the value of the offering that results from the development process. Furthermore, in their quest to keep up with an increasing rate of innovation, many companies are reportedly focusing on their core competencies and technologies, hence out-sourcing many of the activities and competencies they previously nurtured in-house (Quinn, 1999). The rate of technological change in most industries is so high that most companies do not have a choice whether or not to collaborate; they are often forced down this route of action in order to gain access to knowledge-intensive resources, capabilities, and technologies, which they cannot contain inside the boundaries of their own company if they are to remain flexible and agile (e.g. Granstrand *et al*, 1997; Ford and Saren, 2001).

Whereas there are many apparent advantages of collaboration for innovation and technological development the road to collaboration is often paved with obstacles. The management of collaborative relationships is often entirely different from the management of traditional adversarial relationships and requires different capabilities (Möller and Svahn, 2002) and different mindsets. Therefore, although companies may realise the need to collaborate many have reported mixed successes in such ventures. In specific contexts, such as the Japanese automotive industry, collaboration with suppliers for product development has been reported in a major study to have reduced time to market by four to five months and saved vehicle manufacturers around 800.000 engineering hours per car development project (Clark and Fujimoto, 1991, Clark, 1989). However, in other contexts the benefits that have been reported are less clear and outcomes may even be negative. In a cross-industry survey, Hartley (1994) found that there were hardly any or no effects of closer supplier involvement in product development on product costs, quality or development lead-time. The results by Birou (1994) were even more disappointing: she found that the results of supplier involvement in product development across several industries were in fact *negative*, both in terms of development time and product performance. Even though there may be specific methodological problems in the surveys concerned, it would appear that the benefits of collaboration often fail to come to fruition. There is therefore a real need to advance the current understanding of the management of collaborative innovation.

The premise of this thesis is that both the benefits and problems of inter-organisational collaboration can be better understood by adopting a network perspective. Most research to date that has examined the management of collaborative innovation has focused on dyadic (one-to-one) relationships, ignoring the fact these operate within and are influenced by a complex surrounding network. Even in the cases of the so-called 'networks of innovators' or 'innovation networks' (e.g. Freeman, 1991; Oliver and Blakeborough, 1998) little attention is paid to the existence of other relationships of the parties, including other similar networks or alliances in which the parties are likely to be involved. An understanding and conceptualisation of these network influences has been provided by a group of researchers within industrial marketing and purchasing (IMP Group: see for example Håkansson, 1982, 1987, 1989; Ford, 1990; Easton, 1992; Lundgren, 1993; Johanson, 1989; Håkansson and Snehota, 1995). These researchers have effectively contributed to the trend of 'networking' as a means to innovate, but unlike much other research into collaboration, they have also argued the difficulties related to operating within a network of relationships. This implies that any collaboration may be constrained, for example, by the partner having conflicting relationships with other parties in the network (*ibid.*).

One problem that companies face when seeking to collaborate with other parties for innovation is that each of the parties involved is enmeshed in a network of relationship (e.g. Burt, 1983; Ford and Håkansson, 2002; Håkansson and Snehota, 1995; Nohria, 1992). This network is an asset to the companies as it can provide access to a wider set of resources. However, at the same time it limits the control that any one company can exercise over a relationship (e.g. Håkansson, 1987; Ford and Håkansson, 2002; Håkansson and Snehota, 1995; Nohria, 1992). The reason why networks limit individual company control is that the actions and priorities of each of the parties will be influenced by what happens in their other relationships and elsewhere in the network. Some of the companies in these other relationships may act in a way that supports the focal company. Conversely, the actions of others may conflict with those of the focal company. Such conflicting actions may thus constrain attempts at developing and managing innovation by any one actor in the network. Therefore, it is critical for managers to understand the actions and re-actions not only of their immediate partners, but also those of companies positioned further away in the network.

The IMP researchers tend to have a background in industrial marketing and purchasing and their perspective is focused on inter-firm interaction. They have arguably contributed to a more realistic understanding of the complexity of inter-organisational collaboration and management. Nevertheless, the majority of the IMP work on technological innovation in networks has focused primarily on describing, explaining, and conceptualising the nature of dyadic relationships and their embeddedness in networks. Their work has emphasised the constraints of collaborating in networks, but provided little insight into how networks can contribute positively to innovation (see for example Wensley, 1995).

From the 1990s complementary theories of industrial networks have been posed to the IMP perspective by scholars with a background in strategic supply (chain) management, and strategy.[3] This emerging body of research has reported on how powerful manufacturers (often automotive vehicle assemblers) appear to be able to exercise effective control over their networks e.g. Benetton (Jarillo and Stevenson, 1991), Toyota (Womack *et al*, 1990), and Nissan (Nishiguchi, 1994). Like the IMP research, the strategic supply chain research has highlighted the benefits that can be derived from inter-organisational relationships. However, unlike the IMP-orientated research, supply chain and strategic networks research has suggested that individual powerful network actors are in a position to exert power and control over networks and may thereby achieve competitive advantage at the level of the whole supply chain and hence through network deployment.

To date much strategic supply chain research has been observational and anecdotal, describing case examples of firms that appear to have managed their networks and achieved some form of competitive advantage (Johnsen *et al*, 2000). Benetton (Jarillo and Stevenson, 1991), Nike (Lorenzoni and Baden-Fuller, 1995), Toyota (Womack *et al*, 1990), and Nissan (Nishiguchi, 1994) are examples of such descriptive accounts,

[3] The term 'strategic' supply chain management is not used here to suggest one coherent body of research but rather to differentiate between research, which has focused on how inter-organisational relationships can contribute to competitive advantage (such as Womack *et al*, 1990; Lamming, 1996), and more operational logistics-focused research (such as Bowersox *et al*, 1986).

which have been seminal in recent developments in supply chain management (Johnsen *et al*, 2000). Although much supply chain management-based research focuses on operations and supply processes, recent research has also adopted innovation as the unit of analysis. Examples of such research include the concept of supplier involvement in product development (e.g. Clark, 1989; Lamming, 1993; Takeuchi and Nonaka, 1986; Womack *et al*, 1990; Wynstra, 1998). Therefore, whereas some scholars have argued that IMP research has tended to focus on the negative implications of networks (e.g. Galaskiewicz, 1996; Harland and Wensley, 1996), it would appear that researchers in supply chain management and strategic networks have tended to focus on positive exploitation of networks.

This thesis primarily adopts an IMP perspective, however, it incorporates some complementary perspectives, notably that of supply (chain) management. It builds upon concepts and theories that have been developed from within the IMP approach, but extracts some ideas and concepts from supply management, thereby incorporating the best of both theories whilst avoiding their inherent limitations.

1.2. Problem Definition

A central premise of recent research is that individual companies and even supply chains are but part of a large complex network of inter-connected relationships. However, there has been a paucity of research on how companies can manage the innovation process within wider industrial networks; concepts such as 'early supplier involvement in product development' arguably have a predominantly dyadic focus, which tends to underestimate the significance of networks (e.g. Bonaccorsi and Lipparini, 1994; Wynstra, 1998). Companies face a strategic challenge of how they can explore the opportunities existing within the network in which they are enmeshed. Paradoxically, they may need at the same time to cope with the problems and constraints, which networks may exert on the innovation management process. However, the knowledge of different activities that companies may apply to manage the process of innovation and how networks affect these activities, is still to emerge. Thus, the aim of the thesis is to:

- examine how companies deploy the resources and technologies available within their network whilst at the same time coping with the problem of loss of control of knowledge and technologies, during technological innovation

The overall aim sets the direction for the thesis as a whole. Within the overall aim a set of objectives has been developed to:

1. Identify a set of activities that companies apply during technological innovation to draw upon individual dyadic relationships and gain access to resources and technologies available in the wider network
2. Examine how companies draw on networks when managing the identified set of activities
3. Examine the extent to which networks pose a constraint on the management of the identified set of activities

The first objective was formulated to lead to the construction of a set of activities through which network actors may draw upon resources and technologies existing within networks. The objective framed the inquiry within a process perspective, although recognising that innovation processes cannot be fully understood without appreciation of the structural context that is networks. Prior attempts by some researchers to construct similar sets of activities have arguably been partial in scope. For example, Håkansson and Eriksson (1993) and Wynstra (1998) construct sets of activities related to managing supplier involvement in product development. From a network perspective their constructions therefore focus on upstream supplier relationship and network problematics, but pay littler attention to downstream customer relationships. Here the author draws upon experience from a previous (and at some points simultaneous) research project on Inter-Organisational Networking (Project ION: 1996-1999), which constructed a similar set of activities, but in a more generic context of 'managing' in different types of network situations (Lamming *et al*, 2000a; Harland *et al*, 2001; Johnsen *et al*, 2000).

The second objective concerns the positive implications of networks. It involves generating insights into how the set of activities identified might be managed beyond the dyadic relationship level, helping focal actors to draw upon the resources and technologies that can be mobilised through the network. The IMP research has provided important conceptualisations and language for understanding how network actors can deploy and co-ordinate resources and technologies available through networks (e.g. Håkansson, 1989; Ford *et al*, 2003). However, IMP researchers have tended to adopt a rather conservative stance on the question of 'management' in networks (Harland *et al*, 2003) so the complementary perspective of supply chain management and lean supply is used to provide conceptualisations of ways of enabling activities within a network context. The experience and conceptualisation from Project ION provided important insights into this somewhat controversial aspect of network research. In addition, participation in a research project, which was initially known as 'IMP1b' but later as 'Project MaGNet', helped to develop and refine the author's understanding of the problem of 'management' in networks.

The third objective was developed to provide an understanding of the negative implications of networks on the process of managing collaborative innovation. It concerns the consequences of operating in networks, which according to IMP theory (e.g. Håkansson and Snehota, 1995) imply that focal actors have to *cope* with the actions and re-actions of other network actors. Whereas Project ION provided inspiration for the positive side of networks it arguably had less to say about this negative aspect of networks. Hence the existing IMP research has been the primary source of knowledge for this objective.

The combination of the overall objective to identify a set of activities and examining the – positive and negative - network implications on the conduct of the identified set of activities is core to the contribution of this thesis. Arguably, existing research has examined both the positive and negative effects of networks. However, little research to date has examined specifically how individual activities, which are concerned with the management of innovation, may be positively and/or negatively affected by the network in which actors are embedded. The dual consideration of those two conflicting effects is therefore seen as a core contribution of this inquiry.

1.3. Overview of Research Methodology and Approach

The process of collaborative innovation in networks is complex, dynamic and often characterised by a high level of confidentiality. Moreover, the concept of networks is not well understood and often confused with e.g. information or communications systems networks (such as Local Area Networks or LANs). Hence, it is problematic to formulate well-defined hypotheses that allow large-scale surveys to obtain reliable data from respondents. Such practical reasons have often caused IMP researchers to rely on case research methodologies.

As Easton argues (1998, 2002) there are not only practical but also epistemological arguments for adopting case research as the methodology for the study of customer-supplier relationships and network phenomena. In seeking to generate valid explanatory knowledge, positivist researchers rely on analysis of event regularities (correlation) within systems to uncover reality (Ramsay, 1998). Within a phenomenological (or constructivist) paradigm, reality is regarded as socially constructed rather than an objective phenomenon. Human interpretation of meanings perceived in phenomena and events, constitutes reality. Phenomenology differs from positivism in its focus on in-depth understanding of phenomena rather than large-scale empirical hypothesis testing and deductive reasoning. Furthermore, positivist research relies on the study of closed or 'close-able' systems (through isolation and control of variables). As phenomenology is not concerned with uncovering reality through analysis of event regularity (correlation of controllable variables), it requires no such system isolation.

As this research project is concerned with complex and dynamic processes in structures that are by definition open systems, namely networks (Cova *et al*, 1998), it rejects a positivist philosophy. However, it seeks to avoid the inherent trap associated with phenomenological research, that the researcher equates his/hers constructed reality with the reality underlying the constructed reality (Easton, 1998). To avoid this problem, this research project adopted a so-called 'critical realist orientation' (Easton, 1998; Kwan and Tsang, 2001). This implies that although both respondents and the researcher may attach different meanings to phenomena (and thus construct their own reality) what matters is the search for the reality that is not purely subjective.

The choice of a critical realist research philosophy affected the way in which the present research study has been conducted. The project commenced with a review of the literature, which presented the state of knowledge and research related to the field of study i.e. the management of collaborative innovation in networks. The aim of the literature review was not to derive a set of defined hypotheses but rather to develop an understanding of the field of knowledge and to allow for a set of research questions to emerge. During the early stages of the literature review an exploratory mini-survey involving five interviews across five companies was carried out. Following analysis of early empirical findings and further literature investigation, research questions formulated around a conceptual structure were evolved. This guided four in-depth case studies that were conducted, involving 39 interviews with focal companies and key suppliers and customers in addition to three case study facilitation meetings and four follow-up meetings with the main focal company contacts for validation of case findings. Hence, the combination of the study of literature and the exploration of an emerging research agenda served to continuously refine ideas and concepts. It was an iterative learning process, which was *abductive* rather than systematically deductive or inductive (Ayer, 1968). It has been a process of systematic combining of theory and empirical data (Dubois and Gadde, 2002).

1.4. Structure of the Thesis

The report is divided into three parts. Part One sets the scene for the research (Chapter One) and contains a critical review of existing research, key definitions and conceptualisations. Part Two is the empirical part of the thesis. It explains and justifies the research process and methodology and presents the findings from first the exploratory mini-survey and next four in-depth case studies. Part Three contains the discussions and conclusions of the empirical results, comparing these with the findings from the literature review and the conceptual structure. The three parts are divided into nine chapters as follows:

Chapter Two sets out to define and classify the key concepts and terms related to technological innovation. It presents some prominent models depicting the product development process and explains the significance of integrating process development into the product development process. Chapter Two concludes by advancing the argument that innovation by definition entails interaction amongst different actors.

Chapter Three examines the theme of interaction in business markets. It identifies some of the main characteristics of relationships and examines the existing theory and knowledge concerning the role of individual relationships within wider networks. As the meaning of 'networks' is often ambiguous the concept of network is defined and a generic model of networks is introduced. Different types of inter-organisational network are identified and the question of how different levels of analysis and different perspectives on networks affect the way we describe and perceive networks, is discussed.

Chapter Four presents the conceptual framework, which underpinned the empirical investigations conducted as part of the thesis. The framework has been developed from the literature review and undergone iterations following the exploratory mini-survey and the pilot case study. What is presented here represents the final version of the framework. The conceptual structure is examined, including a set of collaborative innovation activities. The chapter concludes by outlining the emerging research questions.

Chapter Five provides an overview of the research philosophy and methodology adopted in the thesis. The chapter begins by discussing the philosophical and epistemological approach adopted, including a brief critical evaluation of three potential philosophies i.e. positivism, phenomenology and critical realism. The chapter discusses the research approach and the research design, relating to the two empirical stages that have been conducted as part of this research: an exploratory mini-survey and four in-depth case studies. The research design section further discusses issues of the unit of analysis, case selection, and analytical methods employed.

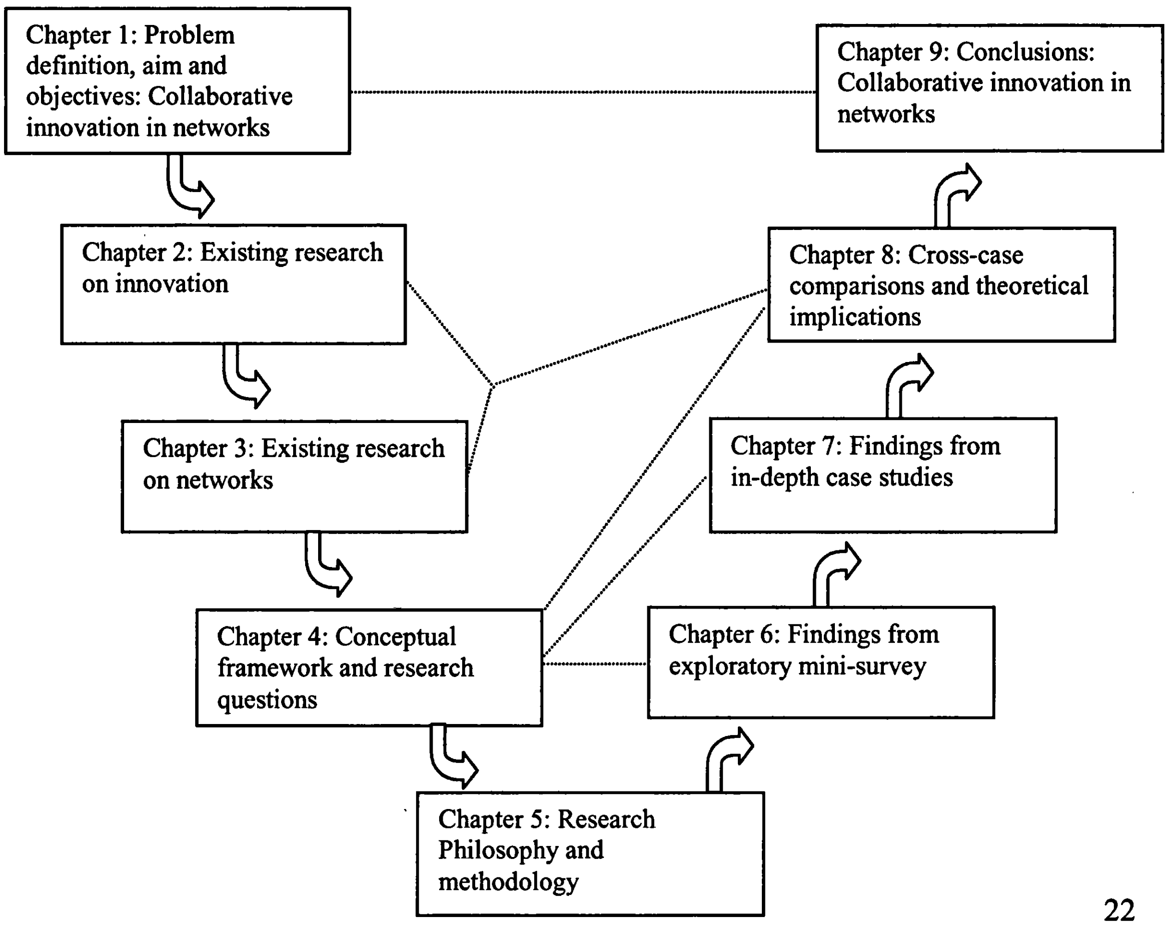
Chapter Six reports on the findings from the mini-survey i.e. a small set of exploratory interviews and discusses some possible explanations for apparent cross-case differences and similarities. A note on methodological and theoretical lessons concludes the chapter.

Chapter Seven reports on the findings from the four in-depth case studies that form the core of the empirical study. Each case is discussed in sequence, identifying the specific context of the case and discussing different network effects on each collaboration activity. An assessment of the performance of each collaboration activity, including the perceived extent of collaboration shown in each activity, is presented.

Chapter Eight presents the cross-case comparisons. This serves to provide an overview of the main findings from the case studies. Thereafter, the research questions, which were set out at the end of Chapter Four, are addressed through analysis of the case study findings and by revisiting the literature. Hence, the contributions of the cases are identified and the implications of the findings are discussed.

Chapter Nine presents the managerial implications and conclusions from the research, addressing the overall aim and project objectives. The contributions and limitations of the study are discussed. The chapter concludes with an outline of avenues for further research. Figure 1 provides an overview of the structure of the thesis, illustrating the principal connections between chapters:

Figure 1. Thesis Structure



1.5. Conclusion

The motivation for doing this thesis was sparked by an academic concern about an apparent lack of understanding of the dual – enabling and constraining - implications of networks on the management of technological innovation. Existing schools of thought seem to place a somewhat imbalanced representation of this duality and appear to consider network implications at a general rather than specific level. Knowledge of different activities that companies apply to manage the process of innovation and how networks affect these activities appears to be lacking. Thus, the aim of the thesis is *to examine how innovating companies deploy the resources and technologies available within their network whilst at the same time coping with the problem of loss of control of knowledge and technologies.*

The thesis (the premise) is that both the benefits and problems of inter-organisational collaboration can be better understood by adopting a network perspective. This argument is grounded in prior research and empirical investigation. The first of these two elements is the subject of the following three chapters.

CHAPTER TWO: THE CONCEPT OF TECHNOLOGICAL INNOVATION

2.0 Introduction

This chapter commences by defining and classifying core concepts and terms related to technological innovation. Having established a platform of innovation terminology, a range of models depicting the product development process is presented. Early models focus predominantly on the development of the product *per se*, whereas later models incorporate required process developments in parallel with the product development process. The final section of Chapter Two shifts the focus towards the interactive nature of innovation, advancing the argument that innovation by definition entails interaction amongst different network actors. This understanding of innovation provides the basis for an in-depth examination of networks in Chapter Three.

2.1 Core Concepts of Innovation

Although the territory of technological innovation is well developed, a number of different definitions of innovation can be identified. The following section seeks to discuss these definitions and classify relevant terms.

2.1.1. Innovation

The Latin word *innovare* means 'to make something new'. Innovation can be regarded as the process of turning opportunity into new ideas and of putting these into widely used practice. This is consistent with the UK DTI Innovation Unit definition (1994) as: "successful exploitation of new ideas". 'Exploitation' is important here, as it differentiates innovation from invention: "innovation is the process by which an invention is first transformed into a new commercial product, process, or service" (Saren, 1984, pp. 11-12). This view is echoed by e.g. Martin (1984) and Roberts (1988).

According to the Frascati Manual, adopted by the OECD (1994), innovation involves the transformation of an idea into a marketable product or service, a new or improved manufacturing or distribution process. The Frascati Manual definition indicates that two types of innovation exist: product and process innovation. Nevertheless, other forms of innovation may be considered equally important: organisational-structure innovations, market innovations and people innovations (e.g. Knight, 1967; Schumpeter, 1935).

Searching through the literature, one realises that it is very difficult to find any agreed definition of innovation. Trying to synthesise the wide variety of definitions, Zaltman *et al* (1973) posit that definitions can be classified into three dimensions each reflecting different perspectives.

The first perspective looks at the process of developing the new item. This perspective is embraced by, for example, Holt who defines innovation as "a process which covers the use of knowledge or relevant information for creation and introduction of something that is new and useful" (1983, p. 13). The second perspective focuses on the process of adopting the new item. Examples of the adopter perspective include Knight (1967) who defines innovation as "the adoption of a change which is new to an organisation and to the relevant environment" (p. 478). To put it differently, this perspective is concerned with the diffusion of innovation into different categories of customer and how they receive and use the innovation (Rogers, 1983). Finally, the third perspective focuses on the new item itself (e.g. Gobeli and Brown, 1987). This perspective analyses the extent to which new ideas, practices, or objects are perceived as new by an individual or other unit of adoption. It often leads to examinations of the degree of newness brought about by the innovation. Each of the perspectives is relevant to this inquiry, although given the objectives of the thesis perhaps mostly so the development process perspective. Whereas it is seen as important to establish the degrees of innovation of projects being studied that is not a primary objective of the thesis. Similarly, the focus on interaction will stress the role of customers in innovation, but the focus will not be on the process of adoption *per se*.[4] The question of degree of change is examined in the following.

Following the perspective of the item being developed, innovations can be classified according to the nature and degree of change, or outcome. Martin has made an early contribution by differentiating between 'normal' and 'revolutionary' innovations (1984). Inspired by Kuhn (1962), Martin's term suggests that a fundamental

[4] The adoption process perspective is often studied in consumer marketing and is concerned with the identification of different categories of adopter, such as 'early adopters' and 'laggards' (Rogers, 1983). In some respects this is equivalent in industrial markets to the research by Von Hippel on 'lead users' (e.g. 1988). This is discussed in more depth in Chapter Four.

transformation of existing belief systems and paradigms is required to bring about a revolutionary innovation.

Gobeli and Brown later proposed a more detailed distinction between 'incremental', 'technical', 'application', and 'radical' innovations (1987). Distinguishing the two dimensions of technological change (the producer's view) and customer benefit (customer's or market view), they define those innovations that involve a low customer benefit and low degree of technological change as incremental. Technical innovations involve a high degree of technological change but low customer benefit, and application innovation involves high degree of customer benefit but low degree of technological change. Radical innovations involve high degrees of both customer benefit and technological change. This classification is comparable with Crawford (1994), Ford and Saren (2001), and Booz, Allen and Hamilton (1982). Such a classification is useful, as it emphasises the equal importance of the technological upstream-driven side and the customer downstream-driven side of innovation. Hence, the model is based on the seminal differentiation and discussion of whether innovation is demand-led (Schmookler, 1966) or technology-pushed (Schumpeter, 1934).[5]

Based on an impressive synthesis of innovation theory, Freeman (1994) has suggested a ranking of innovation on a five-point scale: systemic, major, minor, incremental, and unrecorded. He acknowledges, however, that the most common distinction is simply between radical and incremental innovations. He characterises radical innovations as those needing a new factory and/or market for their exploitation and incremental innovations as the scaling-up of plant and equipment and quality improvements to products and services for a variety of specific application (see also Freeman and Perez, 1988). The term 'novel' also frequently appears in the literature, and would appear to refer to innovations that entail a radical change (see e.g. Von Hippel, 1986; and Tidd et al, 1997). 'Novel' is a useful term as it emphasises that innovation is not only about change, it is about evolving on something new.

[5] In more recent years the debate on the innovation process seems to have reached consensus with the introduction of Rothwell's interactive model (1983), which depicts that neither a linear research/science-to-marketing nor a demand-to-innovation-to-market is sufficient to understanding the innovation process, but an interactive combination of the two.

Scholars focusing on innovations that involve a very high degree of change have developed the concept of 'discontinuous innovation'. In discussing radical versus evolutionary innovation, Abernathy and Utterback (1988) suggest that discontinuous innovations are those that create entirely new market offerings that may be opaque to customers (see also Veryzer, 1998; DeTienne and Koberg, 2002). Kassiecieh *et al* (2002) relate discontinuous innovations to radical, architectural, generational and revolutionary innovations. However, the terms discontinuous and revolutionary may be appealing as they hint at a required shift in technological (and product and market) paradigm (Dosi, 1982). DeTienne and Koberg argue that "discontinuous innovations are not necessarily a matter of magnitude but can comprise altered variations in technology that over time shift the direction of the industry ... discontinuous innovation or variations in technology will augment, shift and change the firm's technological processes and products/services/programs." (p. 352). DeTienne and Koberg thus adopt a more dynamic focus.

Linton (2002) has pointed out that discontinuous innovation involves shifting from one technological learning curve to a more attractive one, thereby obtaining a substantial gain in one or more performance metrics. Hence, discontinuous innovation is about moving from one technological path or trajectory to another (Dosi, 1982; Nelson and Winter, 1977, 1982).[6]

Innovations that involve a supposedly even higher degree of change have been termed disruptive. Kassicieh *et al* (2002) describe disruptive innovations as "scientific discoveries that break through the usual product/technological capabilities and provide a basis for a new competitive paradigm" (p. 375) (see also Linton, 2002).

The view of innovation as revolutionary (Martin, 1984), discontinuous or disruptive (e.g. Kassicieh, 2002) change can be traced to the seminal work on innovation by the Austrian economist Schumpeter who specified that all innovation requires some degree of 'creative destruction' (1942). The fundamental idea is that in order for (particularly

[6] Trajectories describe the direction in which a technology is seen to advance, driven by technology pushes (R&D-led) and demand-pulls (gradual adoption in the market place). Firms may decide to jump on the bandwagon to pursue the 'technological corridor' (Georghiou *et al*, 1986) offered by the trajectory. Dosi describes a technological paradigm as an outlook, a set of procedures, a definition of the relevant problems and of the specific knowledge related to their solution (1982). Hence, a technological paradigm might be seen as a cross-sectoral set of new trajectories (see also, Lamming, 1992).

revolutionary or disruptive) innovation to come about, old assumptions have to be questioned, and 'old' technologies and competencies may need to be 'creatively destructed'. This concurs with Leonard-Barton's findings that core capabilities may both enable and impede product innovation, in the latter case becoming core rigidities (1992) or core incompetences (Dougherty, 1995). As Itami and Roehl have stated: *The time to search out and develop a new core resource is when the old is working well* (1987, p. 54). Thus, both continuous and discontinuous innovation matter (Lamming, 1993) and it requires an element of creative destruction and dynamic capabilities (Teece and Pisano, 1994; Teece *et al*, 1997).[7]

Teece and Chesbrough (1996) mainly distinguish between 'autonomous' and 'systemic' innovation. Autonomous innovations are those that are pursued independently from other innovations. Systemic innovations in contrast are those that are dependent on other, complementary, innovations. The authors refer to Polaroid's efforts to profit from instant photography, which necessitated both new film technology and new camera technology, as an example of systemic innovation. Tidd *et al* (1997) have offered a variation on the distinction between autonomous and systemic innovation. Autonomous innovations concern stand-alone elements whereas systemic innovations concern components in broader systems or architectures. For example, a new type of disc drive represents a product innovation at the component level, but it also makes a contribution to the larger computer system of which it is part.

Whereas most classifications concern purely the degree of change, the scope of innovation, there is also an issue of the extent to which innovations are systemic i.e. scale. In trying to capture this issue, Lundgren (1995) has developed a taxonomy of innovation incorporating both the scope and the scale of the innovation. Lundgren's taxonomy distinguishes between 'minor' and 'major' innovations on the innovation scope dimension, and 'changes to the technological systems' and 'technological revolutions' on the innovation scale dimension. Technological revolutions are not only radical innovations, but also interrelated (Schumpeterian) clusters of innovation amongst several firms (or a whole industry) as a result of a technological breakthrough. Such technological revolutions may enable an industry to leap ahead from its previous

[7] The ever shortening product life cycles across industries over the last few decades is a sign that firms have started to realise the importance of becoming ever more innovative, continuously questioning

technological position. Examples of such technological revolutions include breakthrough fields such as biotechnology and image processing. It is important to recognise that Lundgren's view of technological revolutions is different from that of e.g. Martin, as it adopts an industry rather than a firm perspective.[8]

Some authors view the scale of innovation as reflecting the scope. Earlier work by Freeman (1994) suggested that 'systemic' was at the highest end of the (scope) spectrum, reflecting an even higher degree of change than 'radical'. This view reflects that when product innovations become increasingly radical, associated changes in, for instance, production and marketing systems (but not necessarily the firm) may be needed (Pavitt, 1984). This is also consistent with the definitions of radical innovation adopted by Mensch (1975) and Utterback (1979). Whether it is necessarily the novelty of an innovation, which determines whether it is systemic (if for example a series of inter-dependent yet incremental innovations together formed a significant, but not necessarily radical innovation), is unclear.

Figure 2 synthesises the plethora of definitions discussed here, using Lundgren's taxonomy as a template.

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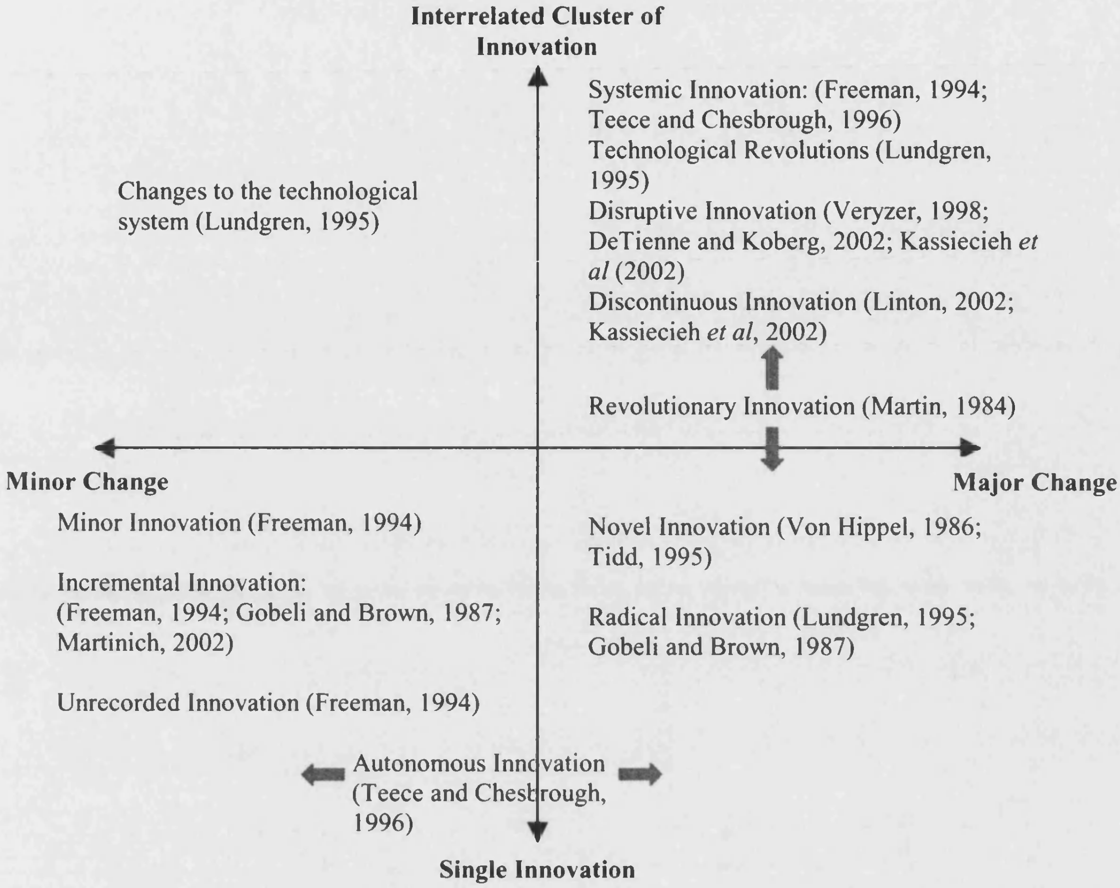
existing accepted or dominant designs of products, processes, technologies, and systems.

[8] Lundgren's discussions of leaping clusters of innovation owe much to the early research on innovation by economists, notably Schumpeter and his followers, whose work on periods of clustered innovations or 'clusters of explosions' followed by periods without such clusters, has inspired, or in some cases directly resulted in, the concept of long term innovation cycles (such as those conceptualised by Kondratiev and Mensch (Mensch, 1979). Those clusters of innovations are formed by the 'swarming' activity as competitors copy and react to the initial innovation i.e. band-wagon effect (Freeman, 1982).

Figure 2. Synthesis of Innovation Classifications



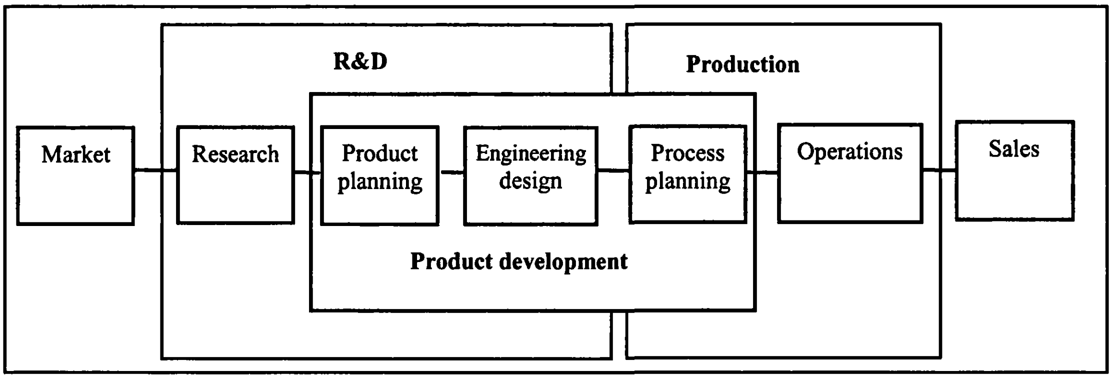
However, the degree of change brought about by an innovation is not objective. What matters is the perceived degree of change or novelty; novelty is in the eye of the beholder (Tidd *et al*, 1997). For example, the implementation of a technologically advanced information system may be a small innovation to a large computer company, but a radical innovation to a small low-tech company where even the use of a simple PC may represent a major challenge. This point is thus consistent with Gobeli and Brown's model (1987) and it emphasises the importance of the two dimensions of newness: new to the world/market versus new to the company.

Innovations involving major change have traditionally been seen as more important than those involving minor change. However, the majority of firms do not generate radical innovations, but develop and adopt incremental innovations first made by others (Freeman, 1994). Indeed lessons from Japan have shown that 'continuous improvement' or *kaizen* may be more important as a competitive success factor (see Womack *et al*, 1990).[9] Moreover, innovation may often come about as a result of the creative combination of old and new technologies; in fact innovations rarely embody only new technology. Hence, the definition of innovation centred on 'first application', while useful as a starting point for analysis, has its limitations. It can be interpreted as lending support to the view of innovations as representing well-defined, homogeneous things that enter the economy at a precise point in time. In reality, most important innovations go through drastic changes over their lifetimes. Subsequent improvements can be significantly more important, economically, than the original invention (OECD, 1994).

2.1.2. Product Innovation and New Product Development

The terms 'product innovation' and '(new) product development' often seem to be used interchangeably in the literature and few scholars attempt to explain the significance of using one term or the other. One scholar who has attempted to define these two terms is Trygg (1991). He views product innovation as including the whole process from market needs to sales, and product development being the phases of product planning, engineering design, and process planning. Figure 3 illustrates the difference:

Figure 3: Innovation and Product Development



Based on Trygg, L. (1991) *Engineering Design: Some Aspects of Product Development Efficiency*, Gothenburg, Chalmers University of Technology.

According to Trygg (1991), the number of stages of development determines whether the process should be regarded as product development or product innovation: innovation includes the whole process from initial market recognition to initial sales, whereas product development only includes product planning, engineering design, and

[9] *Kaizen* emphasises the dominance of continuous, or incremental, improvements, particularly related to

(production) process planning. Trygg's model refers to the development process rather than the outcome of the process. His model is also useful for depicting product development against research and development, portraying the latter involving research, product planning, and engineering, but not process planning. The models of the new product development process discussed later, however, are not all consistent with Trygg's model.

According to Hart (1996) it is the large number of traditionally different disciplines, such as engineering, design, marketing, industrial economics, production management, and technology management, which results in seemingly different terms being used to describe practically the same phenomenon. Hart perceives innovation as a concept describing a higher degree of 'newness' than, for instance, the term 'development'. Hence, she argues that product innovation describes "a new (to the world) product, not necessarily using new (to the world) technology, while a product development would describe further development of a product already in existence" (p. xi). She does, however, recognise the difficulties of adopting such a classification; firstly that it becomes difficult to distinguish between technological development and product innovation and secondly the fact that it ignores the market perspective. In other words, an innovation may be new to a specific market (or industry) but not to the world as a whole. Wynstra suggests (1998) that the term innovation always seems to be related to the discussion of degree of change or newness, and thus favours the term product development, although this suggestion is debatable given Zaltman *et al*'s analysis (1973) distinguishing three perspectives, only one of which focuses distinctly on the discussion of degree of newness.

One concept that is rarely discussed in the literature but is nevertheless frequently used in industry is 'new product introduction'. It can be equated to the launch phase of a new product development project but may also refer to slight variants on existing products or already developed products launched or introduced in new markets (Hines *et al*, 2000). Thus, one new product development project may result in several new product introductions, for example, in different geographical markets. The concept of new product introduction is thus very close to Hart's (1996), arguably problematic, definition of product development.

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process improvements based on continuous learning (see also Bessant *et al*, 1994).

2.1.3. Process Innovation

Process innovation tends to refer to innovation in production or manufacturing processes (e.g. Utterback and Abernathy, 1975; Wheelwright and Clark, 1992). Process innovation is often regarded as a separate form of innovation from product innovation. However, in reality it is difficult to distinguish between product and process innovation as e.g. the user or adopter of a new CAD system may think of it as a process innovation whereas the manufacturer may regard it as a product innovation. It depends on the perspective, as also argued by Biemans (1989).

Together product and process innovations have been categorised as 'technical innovation' (Utterback and Abernathy, 1975) or 'technological innovation' (Johne, 1985, Tidd *et al*, 1997). Utterback and Abernathy (*ibid.*) viewed process innovation as stimulated either by improvements in technology or a wish to minimise cost at the later stage of product development. Their perception was based on the traditional marketing assumption that innovation is need-triggered. As discussed by many authors this may not always be the case as innovations may be technology-driven (e.g. Freeman, 1979). Furthermore, the model can be criticised for viewing process innovation, including cost improvements, as something which primarily takes place towards the end of the product life cycle. Even if this may have been the case in the past, there is a large emphasis in contemporary literature on early, and indeed product life-cycle independent, process innovation e.g. *kaizen*, based on the logic that processes have to be right from the start of product launch. This will be discussed later in this chapter (see also Clark and Wheelwright, 1994; Pisano, 1997).

Pisano (*ibid.*) argues that to understand the strategic role of the process development capability, it is important to explore and establish its context. Pisano's 'Alpha gene' and 'Beta gene' cases highlight three untenable assumptions of Utterback and Abernathy's model:

1. The model focuses on cost reduction as the primary benefit of process innovation; the role of time to market and production ramp-up are ignored.
2. The model assumes that organisational competencies required for product innovation are fundamentally different from - and at odds with - those competencies required for process innovation.

3. The model assumes that specialised process innovation is not needed to enable product innovation. Pisano's Alpha and Beta gene cases show how breakthroughs in process technologies actually enabled the product innovation.

Pisano presents the following matrix for contexts with different roles of product and process innovation:

Table 1: Mapping the Context: Relationships between Product and Process Innovation

Rate of Process Innovation	Low	High
High	**PROCESS DRIVEN** - Commodity chemicals - Steel - Paper Process development focuses on cost reduction	**PROCESS ENABLING** - Pharmaceutical/bio-technology - Speciality chemicals - Semi-conductors - Advanced materials - High precision, miniature electronic goods Process development focuses on solving complex technical problems, rapid time to market, and fast ramp-up
Low	**MATURE** - Apparel - Processed food - Shipbuilding Process development focuses on cost reduction	**PRODUCT DRIVEN** - Software - Entertainment - Work station computers - Assembled products Either little process development or a focus on designs for manufacturability

Low — Rate of Product Innovation — High

Pisano, G. (1997) *The Development Factory-Unlocking the Potential of Process Innovation*, Harvard Business School Press, Boston, Massachusetts.

As Table 1 shows the relative importance of process innovation versus product innovation differs widely across industrial contexts. In industries such as pharmaceuticals or biotechnology it is innovations in new process technology that often allow new products to be developed. The implication of this view is significant, as it dismisses the prior depiction of the role of process innovation as something that occurs later on in the product innovation process (Utterback and Abernathy, 1975). Hence, in certain contexts process innovation is of primary and immediate concern.

2.1.4. Technological Innovation

As discussed in the previous section, technological innovation has been described as an umbrella term for product and/or process innovation. However, technological innovation often refers not only to innovation in finished or assembled products and processes but also to innovation in underlying product and process component technology. A more precise definition, therefore, may be obtained by defining what exactly is meant by 'technology'.

The perceptions of the meaning of 'technology' have undergone important historical development. Historically, the focus on technology has been on the physical aspects. Skinner (1982, p. 464) has defined technology as "the set of physical processes, methods, techniques, tools and equipment by which products are made or services rendered." Nyström (1990) has defined technology as "knowledge that is potentially useful for product and company development, even though the immediate implications may not be clear" (p. 43). Thus, Nyström reflects the recent trend, which is to turn the focus towards knowledge, and in his case specifically related to product and company development. This definition concurs with Ford and Saren's definition of technology, which differentiates between three types of technology: (2001, p. 50-51)

1. Product technology is *knowledge* of the physical properties and characteristics of materials and the *ability* to incorporate these into the design of products or services which could be of value to another company or individual
2. Process technology is *knowledge* of ways of producing products or services and the *ability* to produce these so that they have value to others
3. Marketing technology is *knowledge* of ways of bringing these products and process technologies to a particular application and the *ability* to carry this out. This involves the skills of market analysis, branding, packaging, pricing, communications and logistics.

Ford and Saren (2001) not only see process and product knowledge as the basic components of technology, but they also conceptualise what they call 'marketing technology' as knowledge of ways of bringing these products and process technologies to a particular application and the *ability* to carry this out. Their argument is that developing a product as well as the means to produce it is insufficient to achieve success in the market place if it does not reach customers in a meaningful manner. Their definition is comparable with the one formulated by Lambe and Spekman (1997), who divide technological innovation into three similar parts: 'product technology' being the set of ideas embedded in the product itself, 'process technology' being the set of ideas involved in the manufacture of the product and 'management technology' being the knowledge required to market the product.

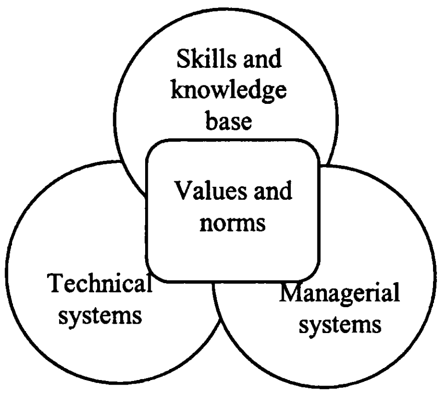
Defining technology in terms of knowledge and ability to act on knowledge puts technological innovation in a very different light, akin to modern definitions of capabilities or competencies. Prahalad (1993) conceptualises core competency as the harmonisation of multiple technologies: "[Sony's core competency of miniaturisation] requires core technologies, such as microprocessors, miniature power sources, power management, packaging, and manufacturing. It certainly also requires knowledge and understanding of user-friendly design and a knowledge of ergonomics. In addition, miniaturization is a result of deep sensitivity to emerging life styles. A core competency does not represent just technical capabilities in microprocessors, or packaging, or passive components; it also means understanding how to exploit life styles knowledge using electronics.... What matters is the creative bundling of multiple technologies and customer knowledge and intuition, and managing them as a harmonious whole" (p. 45).

Prahalad (*ibid.*) conceives competence as being a more aggregate and transcending ability than technology, an ability embedded in the whole organisation. Competencies are also different from 'capabilities' in that these do not necessarily confer any specific differential advantage over competitors. In other words, capabilities may be pre-requisites to 'get into the game' in the first place, but nothing more, according to Prahalad. Competencies are 'distinctive', as originally termed by Selznick to describe 'the character' of the organisation (1957). Therefore, capabilities may be seen as operational whereas competencies are strategic. Elsewhere, however, Prahalad and Hamel (1992) argue that it is not so much a question of whether they are called capabilities or competencies, but rather whether they are core or non-core.

Others have a different perception of capabilities. Teece and Pisano (1994) differentiate capabilities from technologies stating that "the management capability to effectively co-ordinate and re-deploy internal and external competencies;...companies can accumulate a large stock of valuable technology assets and still not have many useful capabilities" (p. 538). Their distinct concept is one of 'dynamic capabilities' where the term 'dynamic' refers to the changing character of the environment and 'capabilities' to the salient role of strategic management in adapting, integrating, and re-configuring internal and external organisational skills, resources and functional competencies toward the changing environment (p. 538). Teece *et al* (1997) perceive a competence as a set of differentiated skills, complementary assets, and routines that provide the basis for a firm's competitive capacities and sustainable advantage in a particular business. Capabilities have also been defined as firm specific 'invisible assets' created and accumulated over time through complex interactions among the firm's resources (see for example Teece *et al*, 1997; Itami and Roehl, 1987).

In her examination of the interaction between activities pursued in the course of developing new products and processes, and the organisation's core technological capabilities (p. 5), Leonard-Barton (1995) has distinguished three types of capability: supplemental, enabling, and core capabilities. Supplemental capabilities are "nice to have - but unessential", enabling capabilities are "the minimum basis for competition in the industry but that, by themselves, convey no particular competitive advantage" while core capabilities are those that "at least potentially provide a competitive edge" (p. 18), hence consistent with the notion of core competencies as developed by Prahalad and Hamel (1990). Her definition of capabilities includes the skills and knowledge base, technical systems, managerial systems (of education and rewards), and (organisational) values and norms (1992):

Figure 4. The Four Dimensions of a Core Capability



Source: Leonard-Barton, D. (1992) Core capabilities and core rigidities: a paradox in managing new product development. *Strategic Management Journal*, Vol. 13, p. 114.

As Tsekouras argues "whatever definition of capabilities/competencies is adopted it is clear that a capability/competence consists of several dimensions some of which are technological and some of which are clearly organisational" (1998, p. 64).

In summary, apart from bringing the concept of technology very close to that of competence, Ford and Saren's definition of three types of technology (2001) is more operational compared with the very wide definition of core competence. By essentially disaggregating the concept of core competence, they attempt to cope with the problem of the core competency approach to strategy[10], being that it tends to constitute *ex post* observations rather than *ex ante* guidelines as to how to develop such competencies, a criticism also echoed by e.g. Iansiti and Clark (1994).[11]

The following section resumes the inquiry into product development to examine how the process of developing new products can be described.

2.2 The Product Development Process

A large number of models depicting the product development process exists. The nature and complexity of the plethora of models that have emerged during the last 30-40 years have changed radically. Most models are so-called 'stages models', assuming that the process of generating new products undergoes a sequential process from early idea generation to product launch. The stages models vary significantly according to their unit of analysis: some are concerned with how the process moves across different departments, others focus on different forms of activity. However, a range of non-stage models also exist, for example so-called conversion models that remove the assumption of an orderly sequential process and instead look at how the process uses different types of input and transforms these into outputs (Quinn, 1985).

It is beyond the purpose of this thesis to seek to develop any new typology of the product development process. In order to provide a brief overview of some of the existing different models the taxonomy proposed by Saren (1984) will be used:

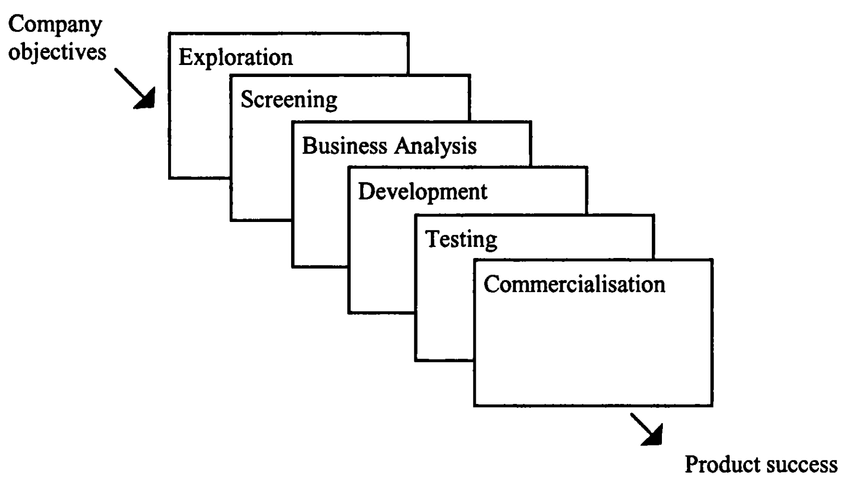
[10] Discussed by for example Porter (1991) in his excellent criticism of the core competence view of strategy.
[11] The problem of building core capabilities/competencies is also the aim of Leonard-Barton (1995) and Nonaka and Takeuchi (1995) in their quest for "The Knowledge-Creating Company".

- Departmental-stage models
- Activity-stage models
- Decision-stage models
- Conversion process models
- Response models

Taking each of these in turn, departmental-stage models focus on the development as it moves from one department to another e.g. R&D, design, engineering, production, and marketing (Saren, 1984). Although departmental-stage models are useful for showing the departmental involvement and responsibility, they say little about the process of product development. Perhaps more importantly, they assume a sequential movement through departments, thus ignoring the importance of departmental overlap and feedback.

Activity-stage models focus on the sequence of distinct activities, which make up the development process (e.g. Utterback, 1974; Wheelwright and Clark, 1992). Perhaps the best-known activity-stage model is the classic model by Booz, Allen, and Hamilton (1971):

Figure 5. Booz, Allen and Hamilton's Activity Stage Model.



Derived from Booz, Allen, and Hamilton (1971) *Management of New Products*, New York: Booz, Allen and Hamilton Inc.

The Booz, Allen, and Hamilton model assumes interdependent stages. This was an important message at the time of publication because it emphasised that individual stages needed to overlap to reduce product development time.[12] The Booz, Allen and Hamilton model is often used in traditional Marketing textbooks (see for example Kotler, 1994). Nevertheless the activity-stage models have been criticised for their inability to illustrate the interactions between the various stages of the new product development process and the assumption that each stage is completed before the next one starts (Moore, 1984).

Decision-stage models adopt a more flexible approach than activity-based models, as they generally do not assume that one step has to be carried out before the next can commence (e.g. Cooper, 1983). The models often specify go/no-go decisions and evaluation points, thereby allowing for decision theory, probability analysis, and computer simulation to assist in decisions. Each decision point is viewed as a small process with information as input and decision(s) as output. Cooper's model assumes a multidisciplinary process, incorporates both market and technological activities, and exhibits incremental commitment and is market-oriented. In recent years the so-called Stage-Gate model (e.g. Cooper, 1993) has been widely applied, for example by Danish Bang & Olufsen (Hansen *et al*, 2002).[13] However, it is arguably a formalised, rational and to some extent bureaucratic model, which may hinder creativity and hence innovation (Hamel, 2000).

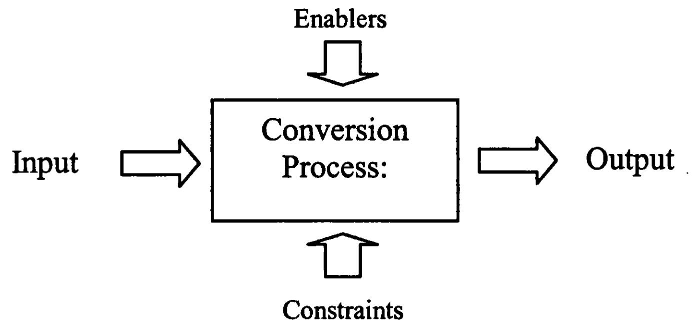
Conversion process models adopt an operations management depiction of input, conversion/transformation process and output (Cooper, 1982). Such models remove the assumption that the process is an orderly and logical sequence (Quinn, 1985). Using the ICAM (ICAM, 1981; Godwin *et al*, 1989) development of the input-process-output model to include consideration of 'mechanisms' or 'enablers', and 'constraints' or 'blockers' (IDEF0), the product development process can be illustrated as below:[14]

[12] Later the authors included "new product strategy development" at the beginning of the process (Booz, Allen and Hamilton, 1982).

[13] Although at B&O the initial idea development stage is separated sharply from the rest of the process, managed by the so-called 'Idea Land' unit.

[14] Historically, the concept of IDEF0 began in the early 1970s when the US Airforce recognised the need to cut costs of aerospace products by increasing its industries' productivity. This led to the introduction of a program for Integrated Computer-Aided Manufacturing (ICAM) being developed as a means of producing efficient manufacturing control and developing automated manufacturing systems. This model has now also been used to analyse design and development processes, including concurrent engineering (e.g. Colquhoun *et al*, 1989).

Figure 6. A Conversion Model of the Product Development Process



Finally, response models are based on behavioural stimulus-response models, focusing on innovation as a response to a change/stimulus. They concentrate on the early stage of inception and include stages such as stimulus, conception, proposal, and adoption/rejection (Biemans, 1989).

The conversion model in the form of a basic interpretation of the so-called IDEF0 (Input-Definition-Output) modelling of the product development process is adopted in this thesis. This is adopted because it offers a simple way to capture and conceptualise network enabling and constraining effects on specific innovation activities. Furthermore, an activity stage model is relied on for collecting data on issues of the timing of supplier and customer involvement in the product development process. The specific activity-stage model adopted is discussed in Section 2.3 (and further discussed in Chapter Five).

2.3. Integration of Process Development into the Product Development Process

As a result of the limitations of early activity-stage models attempts have been made to produce models which include cyclical processes and feedback loops (e.g. Miaoulis and LaPlaca, 1982). In recent years one of the most influential activity stage models is a four phase model proposed by Wheelwright and Clark (1992):

1. *Concept development*
2. *Product planning*
3. *Product/process engineering*
4. *Pilot production/ramp-up*

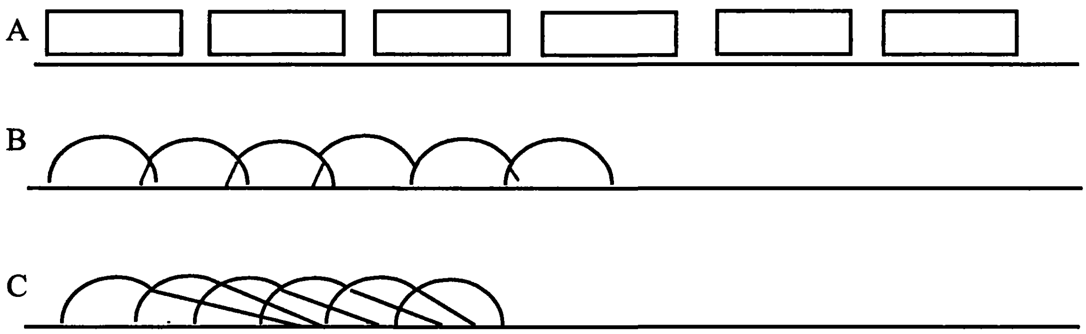
Concept development involves generating ideas from market research, and exploring technical possibilities and product requirements. This phase feeds into product planning decisions on product architecture, conceptual design, desired performance, target market, and investments. Product planning may involve testing, for example, with lead users (see next section). Depending on the outcome of testing, the process moves on to product/process engineering, which entails detailed engineering, prototyping, and development of production tools and equipment. Once - or if - the product delivers the required performance, product specifications are released. This leads to pilot production, which involves low volume pre-series production, factory start-up and modification. Finally, the process undergoes 'ramp-up', gradually entering series production.

Wheelwright and Clark's four-phase model is appealing as it simultaneously focuses on product and process development. Thus, it counters the problem of many earlier models (such as Booz *et al*, 1971), which largely ignored the need for process development. As companies face increasing pressures to reduce time to market (Stalk and Hout, 1990) the integration of process development into product development becomes vital to secure a viable market offering. Furthermore, the model assumes a 'funnel' approach during which unfeasible products are continuously filtered. The model is largely derived from Japanese large scale operations. However with the 'Japanisation' of British industry (Oliver and Wilkinson, 1988) and diffusion of Japanese-inspired innovation methods and principles in the West, Wheelwright and Clark's four-phase model seems to be an accurate depiction of the product development phases used in many (large-scale) Western companies. Consequently, the four-phase model is adopted in this thesis.

Wheelwright and Clark's model (1992) distinguishes four distinct, although interdependent, phases. One of the positive features of their model is that it is based on the assumption of a large degree of overlapping between individual phases. Imai *et al* (1985) have worked extensively on the theme of overlapping development phases. They describe the innovation process as incremental and iterative, characterised by adaptation to the external environment and continuous learning-by-doing: "The key to identifying the various factors that make speed and flexibility possible is to view product development as a dynamic and continuous process of adaptation to changes in the environment" (p. 340).[15]

In their 1986 paper Takeuchi and Nonaka lay one of the cornerstones of what has become known as concurrent engineering (or development). Based on extensive empirical research they argued that the "traditional sequential or 'relay race' approach to product development....may conflict with the goals of maximum speed and flexibility".[16] Inspired by development processes at Honda and Canon they endorsed a holistic or 'rugby' approach, where the development team goes through the entire process (or 'distance') as a unit, passing the ball back and forth. They illustrated the three dominant models of the product development process as shown below:

Figure 7. Sequential Versus Overlapping Phases of Development



A: Sequential development typified by NASA PPP (Phased Project Planning) system
B: Overlapping development typified by Fuji Xerox
C: Overlapping development typified by Honda and Canon

Source: Takeuchi, H. and Nonaka, I. (1986) The new new product development game. *Harvard Business, Review*, January/February: 137-46, p. 25.

The crux of the rugby-inspired Honda and Canon approach is that it not only involves overlaps between subsequent development stages, but also overlaps right across traditionally distant stages, for example, detail product and process engineering may be explored in parallel with concept development. Conversely process engineers working on detail process design may alter or reject product concept or architecture decisions

[15] Although Imai *et al* (1985) emphasise learning-by-doing they also highlight the importance of 'unlearning' as a way to innovate. This chimes with Schumpeter's notion of innovation as creative destruction (1942).
[16] They used the analogy of a relay race to describe how one group of functional specialists would pass the baton to the next group and then seize its involvement.

(Gehani, 1992).[17] The process is thus much more chaotic than portrayed by traditional sequential models (Takeuchi and Nonaka, 1986; Nonaka, 1988), and it allows for cross-functional simultaneous development along three dimensions: market, production process and product (Freeman, 1991; Hein and Andreasen, 1986).[18] Thus, it has been advanced as a way to avoid sub-optimisation within individual departments and to allow 'design for manufacture' (Dean and Susman, 1989; Whitney, 1988; Andersen, 2001). For example, it may provide a way to avoid the problem that the R&D department or product design engineers take the full responsibility for product engineering and therefore do not consider how it can be produced.

The concurrent performance of activities has been identified as one of the pivotal reasons why *lean* Japanese companies have been able to reduce product development time as well as development and product costs (Womack *et al*, 1990; Clark *et al*, 1987). This may not be surprising as the messages are intuitively sound and appealing. However, the literature promoting the concept and practise of concurrent engineering is based largely on empirical observations from Japanese manufacturers and comparisons with US manufacturers. Some commentators (including Takeuchi and Nonaka, 1986) have maintained that the model of concurrent engineering may be of limited value to radical innovation, such as those frequently found in the biotechnology industry, as Japanese manufacturers tend to excel at incremental continuous innovation rather than radical innovation (Doyle, 1985). In other words, the model ignores the cultural context of the study upon which it is based. Furthermore, as Clark *et al* (1985) have admitted, there are dangers in having to commence one phase before the previous one has been completed. Moreover, however theoretically sound, it is arguably a normative ideal, which may be much more difficult to manage in practice as it is based on the premise that different departments or functions are able to collaborate and communicate effectively. Karlsson and Åhlström (1996) have explored some of these practical difficulties that companies pursuing concurrent engineering may experience, and have

[17] The process may thus be characterised by chaos rather than order (Nonaka, 1988).

[18] The cross-functional imperative is by no means new however. It was one of the fundamental findings of the influential SAPPHO studies (Rothwell, 1972; Rothwell *et al*, 1974), the early work by Myers and Marquis (1969), Cooper and his colleagues' Project NewProd (Cooper, 1979; Cooper and Kleinschmidt, 1987). However, as labelled by Brown and Eisenhardt (1995) these studies emphasised a *rational planning* approach, which in many respects contrasts with the much more chaotic approach pursued by modern companies.

highlighted the risks of making costly mistakes, not least because a concurrent approach increases project complexity.

It is apparent from this brief review of the concurrent engineering literature that the original work within this topic focused predominantly on intra-firm processes. The concept has since been taken forward to include supplier involvement (O'Neal, 1993). The majority of the literature, however, still seems to concern intra-firm process integration.

2.4. From Supplier Involvement to Interactive and Collaborative Innovation

One of the defining features of the work on (primarily) Japanese product and process development is that the role of customers and suppliers is recognised (although as concluded in the previous section less so in the concurrent engineering literature). Suppliers are seen as integral members of project teams as they have a salient role not least in ensuring design for manufacture, or process development (Whitney, 1988). Customers are also seen as important, for example as consultants, because they are at the receiving end of the outcome of the development process. However, even in many of the contemporary 'world-class' models of product and process development (e.g. Hines *et al*, 2000) the originator or source of innovation is 'the focal company' itself (e.g. the internal R&D department). There seems to be an assumption in much of the innovation literature that innovation is generated by an individual entrepreneurial company (Håkansson, 1987), although this picture has begun to change.

A fundamentally different view of innovation is to understand this as a process which takes place *between* companies rather than *within* them. An invention may be the product of a lonely inventor; innovation, however, more or less by definition implies that external actors become involved during commercialisation as it reaches the market place.[19]

Von Hippel's seminal research on user-initiated (novel) product innovation from the 1970s pointed out the dominant role of users in idea generation (1976, 1978). His early

[19] In extreme cases of vertical integration it may of course be possible to reach the market place without going through external intermediaries.

study (1976) focused on a large number of successful innovations in scientific instruments, concluding that the innovation process in scientific instruments is a user-dominated process. This picture, however, was later modified, as the source of innovation was shown to vary significantly depending on the industry in focus; scientific instruments, semi-conductors, printed circuit boards, and pultrusion process innovations were shown to be largely user developed, however others have been found to be manufacturer dominated. This led to two paradigms (Von Hippel, 1978): the Manufacturer-Active Paradigm (MAP) and the Customer-Active Paradigm (CAP). The latter is now supported by a number of empirical studies, for example, industrial machinery (Foxall and Tierney, 1984), medical or scientific instruments (Shaw, 1985; Biemans, 1989), software (Voss, 1985) and machine tools (Parkinson, 1982). These studies also contributed to an extension and refinement of Von Hippel's early concept of CAP, extending the role of users to include not only idea generation, but in some cases all stages of product innovation (see also Foxall, 1986 and Foxall and Johnston, 1987).

The seminal work by Piore and Sabel (1984) also highlighted the fact that the large corporation is coming to the end of being the centre of production and innovation. Using data from MERIT - Co-operative Agreements and Technology Indicators[20], Hagedoorn (1995) claimed that 70 per cent of strategic alliances made for the purpose of technology transfer or creation through R&D in the 1980s were in the sectors of the new core technologies of IT, biotechnology, and new materials, and 25 per cent in chemicals, aviation/defence, automotive and heavy electrical equipment. This is hardly surprising given Powell *et al*'s (1996, p. 116) literature finding that "the R&D intensity or level of technological sophistication of industries is positively correlated with the intensity and number of alliances in those sectors" (see also Freeman, 1991).

Håkansson's (1987, 1989) research on supplier-customer interaction during technological development has conceptualised and provided further empirical evidence for the stream of research on user-involvement in product development. His research stressed the interactive nature of the process: "An important and fundamental precept in our work has been that we consider technological development as being the result of the

[20] MERIT (Maastricht Research Institute on Innovation and Technology) - Co-operative Agreements and Technology Indicators is a database containing information on co-operative agreements.

interaction between different corporations, organisations and individuals instead of being the consequence of one individual actor's performance" (Håkansson, 1987, p. 1)

Hence, Håkansson's view is that the process of innovation is always interactive. It is not simply a question of the manufacturer or the customer being the active party, or MAP or CAP. Rather, both parties are active: "An innovation, therefore, should not be seen as the product of only one actor but as the result of an interplay between two or more actors; in other words as a product of a 'network' of actors" (Håkansson, 1987, p. 3).

Håkansson advances three arguments why a company may consider technical co-operation as a suitable, and in some circumstances the only possible, opportunity for technological development:

- Knowledge development
- Resource mobilisation
- Resource co-ordination

Knowledge development is promoted by bringing together different bodies of knowledge that creates two effects. Firstly, an interactive effect which is the result of knowledge being developed at the interface of different bodies of knowledge and perspectives. Secondly, a multi-competence effect which is the result of bringing together diverse knowledge and competencies. Resource mobilisation is important because in order for any invention to be transformed into an innovation it is dependent on other products, systems, and services. The innovation process thus has elements of learning, adaptation, and even socialisation. Resource co-ordination is critical as resource scarcity means that companies specialise their development resources only in limited areas. This co-ordination is handled through a series of exchange relationships linking all units together. According to Håkansson (*ibid*) technological development thus becomes almost synonymous with technological collaboration.

The work by Håkansson represents the school of thought on industrial customer-supplier relationships and networks known as the Industrial Marketing and Purchasing (IMP) Group (e.g. Ford, 1990; Axelsson and Easton, 1992; Håkansson and Snehota, 1990). Albeit many different schools of thought on inter-organisational relationships and networks exist, the IMP Interaction and Network Approach is adopted as the primary theory on which this inquiry leans. This is therefore the subject of Chapter Four.

2.5. Conclusions

In Chapter Two a set of core concepts of innovation that are critical to understand in this inquiry have been defined and specified. These definitions serve as points of reference and concern: innovation, product innovation, new product development, process innovation, and technological innovation.

Innovation is about the making of something new. It encompasses commercial exploitation – if not commercially exploited 'invention' is the proper term (Saren, 1984). The concepts of change and newness are therefore central to understanding innovation. Most scholars now seem to agree that innovation refers to a continuum of degree of change (scope), with terms such as radical, novel, minor, and incremental describing positions along the continuum. Furthermore, innovations vary in terms of scale; whether they are single (or autonomous) innovations or inter-related (or systemic). 'Systemic' will be used in this thesis to refer to inter-related clusters of innovations.

This thesis primarily concerns the development of new products. Here, two concepts are fundamental: product innovation and new product development. The review of the innovation literature found that any distinction between the two is highly ambiguous and problematic. Some authors view product innovation as implying a higher degree of product change than new product development (e.g. Hart, 1996). To add to the confusion, some authors make a distinction between new product development and product development, based on the assumption that new product development is about the development of new products. Hence, this is a very similar definition to that of product innovation. A further problem is that any objective measurement of degree of newness is difficult as innovation is in the eye of the beholder; it may be new to a specific market or industry, or to the world, but it may also be new to the company developing or adopting the innovation (Tidd *et al*, 1997). Based on the broad generic definition of innovation, which encompasses a continuum of different degrees of change, it can be concluded that it is problematic to make any meaningful distinction between product innovation and (new) product development.

Process innovation refers to innovation, or change, in production processes. It is primarily considered in this thesis in its relation to product innovation. However, one of the conclusions from Chapter Two is that process innovation is intrinsically linked to product innovation, as companies are striving for design for manufacture and continuous improvement or *kaizen* (Bessant, *et al*, 1994). Together, product and process innovation constitute technological innovation. This implies that technological innovation comprises application of new product technology (the knowledge and ability incorporated in a product), new process technology (the knowledge and ability of producing a product), and/or new marketing technology (the knowledge and ability of commercialising product and process technologies). Again, the term 'new' is likely not to refer to any radical change but to an incremental upgrade or change. It may also refer to a technology that is simply new to the specific focal company, or the industry, but not new to the world.

A review of a range of models depicting the product development process was undertaken to provide a basis for this study of the management of product innovation. Most of the models reviewed were so-called stages models, which presume a sequential development process. A so-called activity stage model was chosen as appropriate for this inquiry for determining the points at which external collaboration parties may be involved to add value to the process and thus the outcome. This model distinguishes four phases (Wheelwright and Clark, 1992): concept development, product planning, product/process engineering, and pilot production/ramp-up.

However, from the perspective of this thesis a limitation of the majority of product development stage models is that they hardly consider how external parties may relate to the different stages. Considering that the value added by external parties, notably suppliers, during the development process may now equal the value added internally (Møller, 2002) and 80 or 90 per cent of material costs in the final product in industrial companies is now sourced from external suppliers (*ibid.*), the almost exclusive internal focus of product development stage models can be seen as a significant weakness. A non-sequential model was introduced called IDEF0 (Input-Definition-Output). As a conversion or transformation model it is applied in this thesis to conceptualise the process of collaborative innovation.

The lack of an inter-organisational perspective and understanding of the management of product development processes, directed us towards an inter-organisational view of innovation. In recent years many bodies of knowledge have contributed towards the understanding and modelling of inter-organisational behaviour. The Interaction and Network model developed over the last 25-30 years by the IMP Group has been chosen here as the primary approach. This school of thought holds that the locus of innovation is not *within* individual companies but *between* them (Håkansson, 1987, Powell *et al*, 1996). Thus, from an interaction and network perspective innovation is generated through interaction processes between companies. The following chapter thus shifts the analysis towards the Interaction and Network Approach to innovation.

CHAPTER THREE: INDUSTRIAL NETWORKS

3.0. Introduction

The conclusion of the previous chapter was that customer-supplier interaction is pivotal for understanding the process of innovation. The point of departure for this chapter is therefore that industrial customers and suppliers are both active actors who seek to manage, or cope with, other business relationships. The first section of Chapter Three thus examines in more depth how companies interact in business markets. The second section identifies some of the main characteristics of relationships. The third section examines the existing theory and knowledge concerning the role of individual relationships within wider networks. As the meaning of 'networks' is often ambiguous the third section seeks to define the concept of networks and introduces a generic model of networks that helps to understand how individual components of relationships are inter-woven within networks. The fourth section discusses different types of inter-organisational network and further explores how different levels of analysis and different perspectives on networks affect the way we describe and perceive networks. Within this section the two concepts of supply chains and supply networks are examined, with particular reference to how these emergent business forms and practices have influenced the way companies relate to each other at the individual dyadic level and the network level.

3.1. Interaction in Customer-Supplier Relationships

Early models of how companies do business with each other had their roots in, most notably, consumer marketing. Organisational buying behaviour theories (e.g. Webster and Wind, 1972; Sheth, 1973) were based on a consumer marketing model (Kotler, 1994; McCarthy, 1960), in which sellers were seen as the active parties seeking to approach buying organisations to persuade them to buy their products or services. Hence, buying organisations were simply seen as passive recipients. The main problem for the seller was to identify and access the right people in the buying organisation.[21]

[21] Early literature tends to use the term 'buyer-seller' relationships. More recently the term 'customer-supplier' relationships appears to have gained popularity, indicating a shift in emphasis from the relationships between the individual persons with responsibility for buying and selling, to whole organisations as customers and/or suppliers.

Early purchasing models took point of departure from the same basic tacit assumption of one active party seeking to access and mobilise the passive party. However, in the early purchasing literature it was the opposite situation: active buyers dealing with passive sellers (e.g. England, 1970; Lee and Dobler, 1971).

In the 1970s two bodies of theory emerged that laid some of the cornerstones of the later interaction model of buyer-seller relationships: inter-organisational theory (e.g. Van de Ven, 1976) and new institutional economics (e.g. Williamson, 1975). Inter-organisational theory was concerned with the relationship between individual organisations and the environment and relationships between groups of organisations (Håkansson, 1982). The new institutionalists sought to explain the economic rationale of alternative forms of organisation, i.e. their relative efficiency. Having grown out of dissatisfaction with the way in which traditional microeconomic theory viewed inter-organisational relations, the main concern in institutionalist studies tended to be on transactions between companies, which given conditions of uncertain outcomes, infrequently recurring transactions, and high asset specificity (unique or transaction-specific investments), can be performed most efficiently within vertically integrated hierarchies (Williamson, 1975, 1985).[22]

The interaction model was developed by a group of researchers known as the International Marketing and Purchasing (IMP) research group (e.g. IMP Group, 1982; Ford, 1990; Håkansson and Johanson, 1987; Håkansson and Snehota, 1995). The founders of the IMP group began explorations into buyer-seller relationships in the late 1970s and early 1980s. They conducted a large international empirical survey and in-depth case studies of buyer-seller relationships. This study has become known as the 'IMP1 study' (Håkansson, 1982; Turnbull and Cunningham, 1981). It was a study that fundamentally changed the way in which buyer-seller relations and relationships were understood. Rather than studying discrete one-off exchanges or transactions, they focused on long-term aspects of customer-supplier relationships, such as inter-company dependency and evolutions, adaptations, and institutionalisations over time. Furthermore, they recognised the important role of the social interaction that occurred in parallel with the business interaction. Perhaps the most important finding of the first IMP study was the active nature of both supplier and customer. Their model

[22] See Williamson (1985) pp. 95-96 for a discussion of the concept of asset specificity.

fundamentally broke with the tacit assumption of earlier studies and models that one party was active whereas the other was a mere passive agent. Hence the IMP group's approach has become known as the Interaction Approach (IMP Group, 1982; Turnbull *et al*, 1996). The central model resulting from the early IMP study will therefore be examined in more depth in the following section.

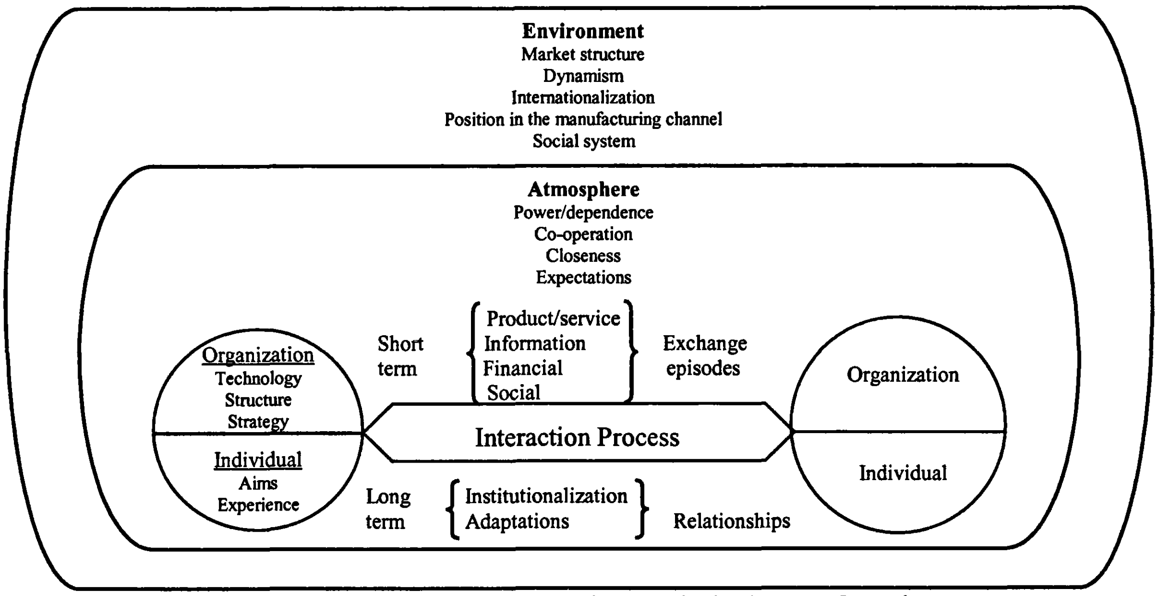
3.1.1. The IMP Interaction Model

The interaction approach is based on continuous 'exchange relationships' occurring between a limited number of identifiable actors (Håkansson and Snehota, 1990). The interaction approach provides a picture of relationships and exchange within them. It is an important conceptual work in trying to understand long-term bonding, various forms of adaptation, and the development of trust and mutuality.

There are four types of variable, which describe and influence the interaction between buying and selling companies (see Figure 8):

- The elements and process of interaction
- The participants involved in the interaction (individually and organisationally)
- The environment in which the interaction takes place
- The atmosphere affecting and affected by the interaction

Figure 8. An Illustration of the Interaction Model



Source: Ford, D. (1990) Understanding Business Markets, 2nd ed. Thomson Learning

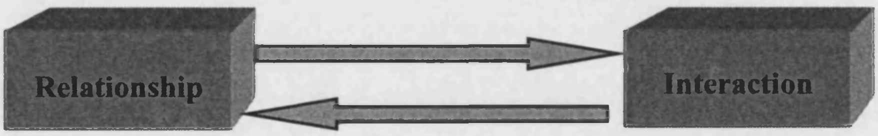
Within the interaction process the interaction model distinguishes between short-term episodic exchange, such as the placing of an order, or long-term exchange within relationships that institutionalise and adapt (Håkansson, 1982). Episodes can involve product or service, information, financial, and/or social exchange. The original model distinguished either product or service exchange, however, the combination of the two into an 'offering' may be a more current perspective (e.g. Ford *et al*, 2003). Information exchange relates to several types of data communication, although in the original model information technology was not included. This has been an important focus of subsequent IMP research, identifying the impact of IT on information exchange processes (e.g. Naudé *et al*, 2002 – IMP1b; Naudé and Buttle, 2000; Walter and Ritter, 2002). Financial exchange is incorporated into the model as a key exchange ingredient. However, the social exchange dimension may be less straightforward, albeit potentially more critical as social exchange has an important function in reducing uncertainty in the relationship (Håkansson *et al*, 1977). Social exchange and bonding (Aldrich, 1979; Granovetter, 1985; Ring and Van de Ven, 1992; Wilson and Jantrania, 1997) has also been linked to the creation of trust, a concept, which has been investigated in much later research as a potential safeguard against uncertainty in the form of opportunistic behaviour e.g. a series of follow-on studies has further highlighted the role of trust in relationships. Trust is seen as an important mechanism, which can contribute (along with other relationship factors such as commitment (Dwyer *et al*, 1987; Ring and Van de Ven, 1994) to preventing the occurrence of opportunistic behaviour (e.g. Sako, 1992; Newell *et al*, 1998; Thorelli, 1986; Kumar, 1996; Smeltzer, 1997). On the basis of Williamson's conception of transaction economics (1975, 1985), Sako (1992) makes a significant contribution to the idea of trust in inter-firm relationships. In the context of her discussions of 'arms-length contractual relationships' versus 'obligations contractual relationships', she distinguishes three types of trust: *Contractual Trust*: The trust that the other party will adhere to the, explicit and implicit, points of the contact as agreed. *Goodwill Trust*: The trust that the other party will perform tasks in excess of the agreed terms and conditions. *Competence Trust*: The trust that the other party has the ability, or competence, to be able to produce what the contract requires. The latter two become more important as the relationship develops over time. In fact, social relationships have been argued as being the very foundation of much described Japanese methods of maintaining efficiency (Sei, 1996). An important point regarding exchange is thus that there is no requirement for a transaction of physical goods to take place. Information or technical knowledge may be sufficient, as long as the exchange is recognised as important by the involved organisations. Thus, relationships can very well be with research institutions, consultancy firms, and service-related organisations (Torvatn, 1996).

Transaction is a one-off exchange that, once completed, could end the exchange process. Continued transactions can lead to a relationship between the parties that ties the parties together economically, technically, and socially. Relationships arise through exchange processes among the parties and over time, repeat transactions enable them to be more routinised (Ford, 1980). Thus the episodic relationship becomes a matter of expectation and a behaviour pattern that is taken for granted and hence institutionalised.

According to the Interaction model (Håkansson, 1982), adaptations and investments required in relationships are important, since they provide an important insight into the change that takes place in a relationship. Adaptations are prerequisites for the development and the continued existence of a relationship; they reflect mutual commitment. Relationship development requires effort and hard work (Huemer, 1998). Adaptations can be made in technical, administrative, and logistic activities. Later research has indicated that although adaptations are important features of relationships, these are not necessarily entirely positive investments, as they may reduce the freedom of actors in developing new relationships due to the sunk, or non-retrievable (Wilson, 1995), costs within existing relationships, and the opportunity cost of adapting for one actor may be foregoing another good partnering opportunity (Han *et al*, 1993; Brennan and Turnbull, 1999; Ford and Håkansson, 2002).[23]

Johanson and Mattsson (1987) later made a further distinction between the relationship and the interaction. They concur with Håkansson in identifying two types of interaction: exchange processes and adaptation processes (Figure 9). Johanson and Mattsson defined a relationship as a contact between two firms that is acknowledged by both parties. In their model, relationships need to have a mutual orientation, mutual dependence, and bonds tying the actors (see also Ford *et al*, 1986). Development models of relationships emphasise gradual probing and reciprocally increasing and deepening mutual expectations and commitment. [24]

Figure 9. Relationships and Interaction in Industrial Markets



Mutual Orientation
- Preparedness to interact
- Mutual knowledge
- Respect for each other's interests

Investments
Bonds
Dependence

Exchange Processes
- Social exchange
- Business exchange
- Information exchange

Adaptation Processes
- Products
- Production
- Routines

Johanson J. and Mattsson L.G. (1987) Inter-organisational relations in industrial systems: a network approach compared with a transaction cost approach. *International Studies of Management and Organisation*, Vol. 18, No 1.

Within the interaction model exchange takes place between two participants or actors. The model differentiates two levels of actors: organisation and individual. At the

[23] Adaptations are conceptually similar to the concepts of asset specificity and transaction specific investments often used in transaction cost economics (Williamson, 1985), although the focus is on (long-term) relationships rather than discrete transactions. See also Johanson and Mattsson (1987) for a comparison of network theory and transaction cost theory.

[24] It is arguably problematic to restrict the definition of relationships to those including a mutual orientation. Mutuality may grow over time, however, a relationship may also lack this dimension. The important issue is not to identify whether or not a relationship exists or should be created, but to understand the nature of relationships (Turnbull *et al*, 1996; Blois, 1998).

organisational level technology plays a prominent role, as it sets the basic conditions for the interaction. Not surprisingly, this dimension has received extensive attention in further IMP research (see Håkansson, 1987, 1989; Ford and Saren, 2001). Furthermore, according to the interaction model (Håkansson, 1982) organisational size (including power), structure, strategy and experience determine the relative positions of each party. The important issue here is that these factors are considered at the relationship level rather than in relation to an anonymous competitive environment or industry. At the individual level the buyer and seller (at each side of the relationship) are the key actors, however, increasingly a much wider range of cross-functional personnel is involved in the process. Individuals may have their own aims and experience, which will affect their behaviour and performance. The importance of social bonds is emphasised as an important factor in this process of interaction amongst persons.

The interaction environment consists of market structure, dynamism, internationalisation, position in the manufacturing channel (what is now often seen as the value or supply chain), and the social system (Håkansson, 1982). One of the important messages in this regard is that the environment is seen as 'enacted': individual actors are part of the environment and can influence, and in turn can be influenced, by the environment (Weick, 1979). More recently, Ford and Håkansson have described this as a view of the environment being 'interacted' (2002).

The atmosphere encapsulates the interaction process and can be described in terms of the power-dependence relationship between the parties, the level of conflict and/or co-operation, overall closeness or distance and mutual expectations (Håkansson, 1982, p. 20). The economic dimension of the interaction is captured through the closeness of the relationship, for example, a close relationship has the potential to reduce transaction costs. The control dimension concerns the power/dependence position of the two parties. Power/dependence is a salient and complex concept, which deserves a few words of explanation.

The interaction model portrays power as one of a number of relationship characteristics constituting the atmosphere, although such a view may be criticised for demoting the role and importance of the power/dependence dimension (see for example Caldwell, 2003).[25] Power may be defined in the following terms: "the power of actor A over actor B is the amount of resistance on the part of B which can be potentially overcome by A" (Emerson, 1962, p. 32). In other words, power is concerned with the ability to persuade another person to do something that he or she would not otherwise have done (Dahl, 1961). Lukes (1974) later identified that the exercise of power involves conflict and that the control of resources or knowledge by one actor in excess of that of another enables that actor to make decisions and achieve outcomes (see also Fairhead and Griffin, 2000). Accordingly, power is concerned with the visible control of one actor by another through wielding power gained via superiority or sovereign power, what can be described as a one-dimensional or utilitarian view of power (Lukes, 1974). Conversely, power may be used less overtly to influence the process of decision-making so that certain issues are never allowed to emerge (Bachrach and Baratz, 1970). Such a dispositional view of power concerns 'behind the scenes' effects on behaviour that prevent events or outcomes; it is covert and subtle (Lukes, 1974; Caldwell, 2003). "Power resides implicitly in the other [actor's] dependency" (Emerson, 1962, p. 32), but as argued by Provan and Gassenheimer (1994) not all organisational dependencies are related to actual influence, as power may not always be enacted or exercised. Their further argument, however, that "dependencies built on long-term co-operation and deferred gratification may well result in different power outcomes at any given point in time than dependencies embedded in a relationships where commitment is low, in which short-term norms of self-interest drive behaviour" (p. 56), may be dubious. Ford *et al* (2003) have pointed out that reliance on trust and collaborative working does not mean absence of power and conflict, as firms become increasingly inter-dependent (p. 148). Nevertheless, power may be applied either coercively or in a collaborative way (Frazier and Antia, 1995); coercive power may often be applied in low-involvement or adversarial relationships, but is less appropriate for high-involvement collaborative relationships (Ford *et al*, 2003).

The relationship between power and dependence implies that co-operation and conflict co-exist within the relationship, making relationships more complex than a simple matter of degrees of closeness. Indeed, any attempt to understand relationships along a simple continuum ranging from e.g. 'close' to 'distant' or 'good' to 'bad' would be an

[25] Some authors view power as a more fundamental characteristic and driver of business (and non-business) relationships (see for example Cox *et al*, 2000).

oversimplification; relationships have too many dimensions to fit into such classifications (Turnbull *et al*, 1996).

In summary, the interaction approach has focused on relationships between actors as the central unit of analysis rather than the individual transaction. Hence, the long-term processes have tended to be the main body of concern in the interaction approach. This implies that co-operation and collaboration are critical elements of industrial customer-supplier relationships. The conceptual difference between collaboration and co-operation is far from clear however.

3.1.2. Collaboration and Co-operation

The previous section identified co-operation as part of the relationship atmosphere, along with power and dependence, closeness, and expectations. Thus, co-operation can be seen as a fundamental characteristic of industrial customer-supplier relationships.

A scrutiny of the relationship and network literature shows that although many authors frequently refer to both collaboration and co-operation, few definitions of collaboration exist. Håkansson and Henders (1992) have provided a broad definition of *co-operative relationships* as "those relationships where the counterparts have realized, and begun to exploit the benefits of working together- the relationship is characterized by co-operative rather than contentious interaction" (p. 35). Formalisation of the co-operation is not seen as an essential ingredient, but rather the organic growth of the relationship over time.

Stern (1996) has defined *co-operation* as "behaviour that involves joint striving for a goal or object, is direct or indirect (explicit or implicit), and personal, in which the goal or object that is controlled by a third party can only be secured if the focal parties coalesce" (p. 4). In a similar vein Araujo and Mouzas (1997) state that co-operation involves a combination of object-centred and collaborator-centred activity based on compatibility of goals, aims, and values. Therefore, following the definition by Araujo and Mouzas, co-operation is defined by reference to collaboration and thus indicating little difference between the two concepts. Similarly Anderson *et al* (1994) define co-operation as "similar or complementary co-ordinated activities performed by firms in a business relationship to produce superior mutual outcomes or singular outcomes with expected reciprocity over time" (p. 10). Ring and Van de Ven (1994) view co-operation more broadly as characterising a particular form of inter-organisational relationship, however, this thereby reverts to a definition of collaborative relationships rather than collaboration *per se.*

Synthesising the above contributions it seems that co-operation and collaboration are often used interchangeably to imply behaviour and/or relationships involving mutuality, sharing, reciprocity, goal, and value compatibility. These are indeed many of the defining features of relationships (Johanson and Mattsson, 1987), although arguably not all relationships need to be collaborative.[26]

It is apparent from the review of the relationship and network literature that there are few specific definitions of collaboration. Thus resorting to the Oxford Advanced Learner's Dictionary (2003) it defines collaboration as "the act of working with another person or group of people to create or produce something". In comparison, it defines co-operation as "the act of doing something together or of working together towards a shared aim". Hence, according to these definitions both concepts involve 'working together' and are therefore descriptions of joint acts (or activities). However, collaboration is related to the creation or production of 'something' thus indicating a tangible outcome, whereas co-operation seems to imply 'shared aims' (of which a tangible outcome of course could be one such aim). For this reason, collaboration is viewed as the more appropriate term for describing product innovation (as the creation of a tangible product is the intended outcome of product innovation) and is hence the term adopted in this thesis. It is a broad and inclusive definition. Whether relationships are collaborative or not is a matter of degree rather than a question of either/or.

The discussion of definitions of collaboration and related concepts implies that there are supposed benefits of such joint activity. Nevertheless, the findings of empirical research into the actual results of collaborative innovation are not altogether positive.

[26] See Johnsen and Ford (2002) for a recent conceptualisation of relationship characteristics.

3.1.3. Empirical Evidence of Actual Results of Collaborative Innovation

Searching for empirical evidence of actual performance results of customer-supplier collaboration for innovation, one finds that the existing research either analyses the impact of supplier involvement on product development or the impact of customer involvement. Thus, the main bulk of the studies that can be found does not adopt an interaction perspective. The body of research regarding supplier involvement in product development seems to have provided the more rigorous findings (although many findings are still rather anecdotal). Given that these studies effectively concern customer-supplier collaboration, albeit adopting a broadly non-interactive perspective, they are used here as proxies for collaborative innovation in relation to both suppliers and customers. Table 2 provides an overview of some of the most significant empirical findings on supplier involvement in product development to date.

Table 2 Empirical Findings on Supplier Involvement in Product Development

Authors	Findings
Clark and Fujimoto (1991)	Japanese auto study: reduced time to market by 4-5 months + saved vehicle manufacturers app. 800.000 engineering hours per car development project (Clark and Fujimoto, 1991, Clark, 1989).
Hartley (1994)	Study of 79 SMEs: industrial equipment, computers, and analytical instruments: Insignificant effects on product costs, quality or development lead-time.
Birou (1994)	Study of 83 US automotive, electronics, defence, and medical equipment firms: negative effect. Higher product and development costs, often longer development time and product performance.
Ragatz *et al* (1997)	Study of 60 companies: improvement of 40 per cent for product quality, 25 per cent for development cycle time, and 15 per cent in product costs.
Bruce *et al* (1995)	Increased process complexity, no effect on market responsiveness, no facilitation of incorporation of new technology.
Bidault and Butler (1995)	Reduction of development time by 30 to 50 per cent (experienced manufacturers).
Dröge *et al* (2000)	Study of 57 first tier North American auto suppliers. Found significant relation between 'supplier closeness' (consisting of supplier development, supplier partnership and JIT purchasing) and development time ability.
Eisenhardt and Tabrizi (1995)	Exploring a set of rapid 'adaptive processes' (including supplier involvement) across 72 development projects within 36 Asian, U.S. and European computer firms. Mixed results.

In a major comparative study of the automotive industry (International Motor Vehicle Programme: IMVP), Clark and Fujimoto have reported that collaboration with suppliers for product development in Japan resulted in the reduction of time to market by four to five months and savings of around 800.000 engineering hours per car development project for vehicle manufacturers (Clark and Fujimoto, 1991, Clark, 1989). These findings were also reported in Womack *et al* (1990). Out-sourcing of 'black-box' parts, where suppliers conduct detailed engineering based on functional specifications provided by vehicle assemblers, seemed to be a key explanatory factor in their study. The widely-cited study by Imai *et al* (1985) provides important complementary results to the IMVP-based findings.

However, in other contexts the benefits that have been reported are less clear and outcomes may even be negative. In a cross-industry survey, Hartley (1994) found few or no effects of closer supplier involvement in product development on product costs, quality or development lead-time.[27] Eisenhardt and Tabrizi (1995) explored a set of rapid 'adaptive processes' (including supplier involvement), and reported mixed results on development time. There was a limited correlation between supplier involvement and pace of development times, although more technologically predictable projects showed a more positive effect on development time due to the more certainty regarding which suppliers to use; less predictable projects showed no significant effect. Yet this is inconsistent with the findings of Wasti and Liker (1997).[28] The results by Birou (1994) were even more disappointing: in a study of 80 U.S. firms she found that the results of supplier involvement in product development across several industries were in fact *negative*, both in terms of development time and product performance.

On the basis of a study of 25 European, US and Japanese manufacturers into early supplier involvement in product development, Bidault and Butler (1995) claimed a correlation between the level of experience of supplier involvement and manufacturers' reducing development time by 30 to 50 per cent; the level of experience implying a focus on quality improvements rather than cost reductions. Bruce *et al* (1995) found that many respondents stated that collaboration makes product development complex and difficult to control and manage, that is does not make it respond better to market opportunities, and does not facilitate the incorporation of new technology.

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[27] In a later project of assembler firms Hartley *et al* reported that working with suppliers with technical capabilities reduced development time (1997).

[28] Wasti and Liker examined the link between the level of supplier involvement and technological uncertainty of components. This may indicate that although development time is not reduced in such projects, supplier involvement is nevertheless prevalent and important in technologically uncertain and complex projects (see also Kamath and Liker, 1994).

Ragatz *et al* (1997) presented findings from 60 companies indicating that the most successful cases of supplier involvement resulted in median improvement of 40 per cent for product quality, 25 per cent for development cycle time, and 15 per cent in product costs. It was not measured, however, how many successful projects the companies have had, hence difficult to draw overall conclusions. More recently, Dröge *et al* (2000) have reported a significant relationship between what they term 'supplier closeness' (a jumble consisting of rather diverse factors, including supplier development, supplier partnership and JIT purchasing) and development time ability. The highly statistical nature of this study, however, arguably contains little analytical depth.

Interpretation of the divergent empirical results needs to be based on an appreciation of not only regional and industrial differences, but also trends in customer-supplier relationships. When studies of supplier involvement in product development first emerged in the late 1980s and early 1990s, Japanese companies were far superior to their western counterparts in their ways of involving suppliers in product development (e.g. Clark and Fujimoto, 1991). The empirical results point to the importance of experience in supplier involvement as well as working with competent counterparts. Takeishi (2001) has recently highlighted the importance of developing and maintaining internal capabilities (particularly architectural knowledge) in order for firms to be able to co-ordinate and thence capitalise on external collaboration with suppliers; an absorptive capacity needs to be present (Cohen and Levinthal, 1990). Furthermore, effects of supplier involvement can be very difficult to measure, as all projects are heterogeneous and the effects are ambiguous. The fact that projects tend to be analysed in hindsight does not help reliability due to the unavoidable risk of biased *ex post* evaluations.

Finally, not all benefits of involving suppliers in product development can be measured by project outcome results. Some impacts are long-term and strategic rather than short-term and operational, such as the potential for increased efficiency and effectiveness of future project collaboration (Dyer and Ouchi, 1993) and improved possibilities for influencing future technological investments (Van Echtelt and Wynstra, 2000). Thus, long-term learning may be a salient factor in avoiding negative outcomes of individual project collaboration.

In summary, although there may be benefits to be reaped from collaborative innovation the empirical evidence tells us that the process is difficult to manage and may therefore not lead to the expected results. This implies that there is a real need to advance the current understanding of the management of collaborative innovation. The premise of this thesis is that some of the problems of managing collaborative innovation pertain to the need to understand individual dyadic relationships from a network perspective. Indeed, inter-dependencies in and between relationships and thus networks were the subjects of the second IMP study (Håkansson and Snehota, 2000). The network perspective of customer-supplier relationships and its implications is therefore examined in the next section.

3.2. Understanding Relationships as Parts of Complex Networks

Although the IMP interaction model (Håkansson, 1982) advanced the level of understanding of what happens within relationships at the dyadic level, it was not until relationships became understood as parts of networks of relationships that a more complete and complex understanding of relationships emerged.

From a network perspective relationships are viewed as a parts of a larger whole - a network of interdependent relationships (Håkansson and Snehota, 1995; Ford *et al*, 2003). These relationships are 'connected' since what happens in one relationship affects positively or negatively the interaction in others (Cook and Emerson, 1978; Blankenburg and Johanson, 1990). This implies that what happens in a relationship between two companies depends upon a number of other direct or indirect relationships within which the two parties are involved.

The problem with the network perspective is that the concept of 'network' itself has become overused and often tends to be ill defined. The following section thus seeks to define in more specific terms the precise meaning of 'network'.

3.2.1. Defining Networks

One of the early definitions of networks was provided by Mitchell (1969) who referred to a network as a specific type of relation linking a defined set of persons, objects or events. The set of persons, objects or events of which the network is comprised can be called 'actors' or 'nodes' (Ford and Håkansson, 2002; Mitchell, 1969). Cook and Emerson (1978) defined *exchange networks* as: "a set of two or more connected exchange relations" (p. 725). They later specified that in a business context networks are sets of connected exchange relationships between actors controlling business activities (1984). "*Connected* refers to the extent to which 'exchange in one relation is contingent upon exchange (or non-exchange) in the other relation" (Cook and Emerson, 1978, p. 725). Thus, Mitchell (*ibid.*) and Cook and Emerson (*ibid.*) used 'sets' to define networks thereby indicating that networks consist of a number of actors or nodes, albeit no minimum (or maximum) number was specified.

In recent years, however, the concept of 'network' has often been used rather loosely. As Nohria has pointed out, the frequent "indiscriminate proliferation of the network concept threatens to relegate it to the status of an evocative concept, applied so loosely, that it ceases to mean anything" (1992, p.3). Part of the problem is that as a concept 'network' has been used and has attracted scholars from many different fields. Easton (1992) draws upon Mintzberg's five alternative metaphors for understanding strategy (1992) to suggest four metaphors for *industrial networks*: - networks as relationships, structures, processes, and positions.[29] Consequently, Easton defines 'network' as a model or metaphor which describes a number, usually a large number, of entities which are connected. The use of the word 'metaphor' in Easton's definition hints at one problem with networks, namely that 'network' often means different things to different people, and thus perhaps constitutes a fifth metaphor or a 'meta-metaphor': network as perspective. In any case, the way networks are defined and perceived will not only affect the way we think networks function, but also the way we focus our interests and delimit our problems (*ibid.*). Table 3 provides an overview of Easton's four metaphors of networks.[30]

[29] The use of 'metaphors' for understanding networks is inspired by Morgan's (1986) use of metaphors as a means to analyse and perceive organisations, such as a cultural or a political metaphor.
[30] The table is mostly based on Easton's analysis, although examples of some more recent contributions have been added here.

Table 3. Four Network Metaphors

	Networks as Relationships	Networks as Structures	Networks as Positions	Networks as Processes
View of networks	Networks as aggregations of relationships	Networks as interdependent firms	Networks as aggregation of interlocking positions	Networks as evolutionary industrial systems
Unit of analysis	Industrial customer-supplier relationships	Activity, actor, and resources structures	Focal firms in networks	Change processes in relationships and networks
Issues	Interaction Mutuality Dependency, power and control Actor bonds Relationship investment, Adaptation	Division of activities and resources Network boundary Heterogeneity	Strategic actor identity Network role Network function Actor attractiveness Entering and exiting networks	Evolution processes Network inertia Innovation
Exemplary Contributors	Ford (1980); Ford, Håkansson and Johanson (1986), Håkansson and Snehota (1998); Wilkinson and Young (1994); Anderson, Håkansson and Johansson (1994)	Håkansson and Johanson, (1992); Dubois (1998); Håkansson and Snehota (1995)	Mattsson (1984); Johanson and Mattsson (1987, 1992); Håkansson and Johanson (1988)	Lundgren (1993); Håkansson and Waluszewski (2002); Hertz (1996)

As Table 3 shows, network phenomena have been analysed by a wide range of scholars for a wide range of purposes and perspectives. Arguably Easton's presentation of research in the field leans heavily towards contributions made by IMP group members. Elsewhere he (with Araujo) makes it more apparent that the field has been developed by researchers from many different fields (Araujo and Easton, 1996). Indeed Araujo and Easton (*ibid.*) identify ten fields of network related research, classified amongst other factors according to factors such as the disciplinary background of contributors, research goals, and methodological orientation. The implication of their analysis is that although the IMP school of thought on networks may be seen as very influential it is but one school of thought.

Owing to such a variety of different network forms and ways of using the concept of 'network', it is useful to identify a set of meta-level classifications. Easton (1992) identifies three broad definitional groups: one set of definitions describes a network as the total pattern of relationships within a group of organisations acting in order to achieve common goals (Van de Ven and Ferry, 1980). The second set of definitions focuses on the bonds or social relationships that link loosely connected organisations (Aldrich, 1979, Lundgren, 1995). The third set of definitions focuses on the exchange dimension in two or more connected relationships, where exchange in one relationship is contingent upon exchange in another (Anderson *et al*, 1994). The components of exchange within the relationship can include the product or service, information, and financial and social elements. These three groups of definitions each reflect different levels of analysis.

Hence, the assumption of Van de Ven and Ferry's definition (1980) seems to be that a network consists of a group of organisations that are all driving towards the same goal. This is therefore, in many ways, akin to the concepts of 'group' or 'coalition' (Pisano *et al*, 1988). The concepts of *strategic networks* (Jarillo, 1988), *networks of innovators* (Freeman, 1991; Debresson and Amesse, 1991) or *innovation networks* (Oliver and Blakeborough, 1998), and *learning networks* (Bessant and Tsekouras, 2000) all fall within this definition. The second definition (Aldrich, 1979, Lundgren, 1995) specifically addresses the issue of network boundary by stating that the organisations involved are 'loosely connected', which implies that, by definition, it is problematic to conceive of a fixed boundary surrounding a network (Cova *et al*, 1998). Networks include both strong and weak ties (Granovetter, 1973; Uzzi, 1998). This has important implications for the use of the concept, including the type of analysis one can conduct. Finally, Anderson *et al*'s definition (1994) focuses particularly on the 'connectedness' aspect, hence not addressing the issue of network boundary, but shifting the focus towards inter-connectedness between what are effectively dyadic relationships. Thus, in their definition, a network is not something 'out there', but a particular perspective. An overall feature of the various definitions seems to be that networks entail inter-connectedness and/or inter-dependency. This issue will be discussed in more detail later.

The concept of *industrial networks* adopted by Johanson (1989), falling under Easton's third category (1992), specifies that industrial networks are coupled to industrial activities and hence not to be confused with *social networks* (e.g. Brass and Burkhardt, 1992), although the social aspect of any network is always an important feature (Nohria, 1992). This therefore excludes purely social links (those not linked to industrial activities), but still emphasises that there is no such thing as a network boundary. This also implies that industrial networks are not designed, but emerge as a consequence of exchange between semi-autonomous, inter-dependent actors (Johanson, 1989). As Johanson explains, strategic networks may be embedded in industrial networks, but are not the same. Håkansson and Snehota's term *business network* (1995) follows Johanson's line of thinking, although the term 'business' implies a slightly wider focus than the manufacturing focus implied in the term 'industrial'.

Thorelli (1986) has contended that networks (in the generic sense) are neither markets nor hierarchies but an intermediate form. Nevertheless, it may be possible to conceive of a continuum of networks. At one end is the 'networks as markets' approach, which is evident in the IMP approach, where the concept is generally used to provide a better understanding of how companies and markets are inter-woven through complex relationships (Easton and Håkansson, 1996). At the other end is the 'networks as organisations' approach which is evident e.g. in the research by Cravens *et al* (1995) but also in the concept of, for example, *supply networks*, as will be discussed later. Such a continuum derives from an institutional economics conception of organisational forms – free markets, vertical integration, or bilateral governance (Williamson, 1975). Institutional economists analyse many of the same issues as industrial network researchers, including forces of friction and inertia in customer-supplier relationships; such friction is conceptualised as transaction costs in institutional economics. Institutional economics, or transaction cost economics (TCE) is, however, limited in its assumptions of equilibrium under cost minimisation and economic bounded rationality (Easton, 1992), and consequently of its assumption of opportunism as standard (rational) behaviour.

Building on the work by Möller and Halinen (1999), and Möller *et al* (2002), the author suggests thinking along a four-level framework:

Table 4. Four Levels of Analysis in Network Research

Level of Analysis	Key Themes
Level 1: Industries as Networks	Networks: configurations of actors and value activities Understanding network structures, processes and evolution Influencing and coping with inter-connected actors
Level 2: Focal Net(work)s	Groups or coalitions of firm with common purpose, defined according to particular purpose of analysis Mobilising and co-ordinating key actors Managing network positions
Level 3: Relationship Portfolios	Portfolios: multiple relationships classified along, typically, two dimensions Balancing relationships: investment relative to relationship intensity Appropriate relationship development and management
Level 4: Exchange Relationships	Dyadic relationships: building block of networks Relationship analysis and management Understanding past, present and future direction of relationships

The implication of Table 4 is that research on networks can legitimately be conducted at different levels and for different purposes. There are inevitable advantages and disadvantages of different levels of analysis. For example, macro analysis at level one is likely to result in a holistic and comprehensive understanding of the inter-connectedness of network actors and actions, behaviour, and developments that may impact on the future actions of several network actors. However, the management perspective of any one focal firm is easily lost in the complexity. Conversely, analysis at a more 'micro' network level may help to generate a more actor-specific perspective, but at the expense of the more complete understand of wider network changes.[31] The subject of inquiry of much IMP research appears to relate to levels one and four (and to a lesser extent three) and the interplay between these levels. Level two is arguably one level of analysis, which has not been explored to the same extent by the IMP group. However, the research by scholars from outside the IMP group, such as Jarillo (1988) and Lorenzoni and Baden-Fuller (1995), can be classified within this category. Gemünden's analysis of the trend in unit of analysis in IMP proceedings from the early 1980s to the mid-1990s (1997) would appear to endorse this perception.[32] The network focus in this thesis is on focal firm networks and relates predominantly to level two.

31 The relationship between relationships and networks bears resemblance to the 'Hermeneutical Circle' (Gadamer, 1960), which shows that parts give us a sense of the whole, but in order to understand the significance of the whole we have to appreciate the parts (although the whole is never fully realisable through the parts). The thinking can be usefully transferred to how relationships and networks need to be understood. One needs to understand (individual dyadic) relationships in order to understand and sense networks (as networks consist of relationships); conversely one needs to appreciate networks in order to understand relationships (as these are embedded in, and thus affected by, networks).

32 It is not entirely clear in his analysis how 'network research' was measured and classified

The following section pursues the inquiry of the substance or building blocks of networks. This will be explored by examining a central IMP model of networks.

3.2.2. A Network Model: Actors, Resources, and Activities (ARA)

The IMP network model suggests that the core elements of any network are actors, activities, and resources (Håkansson and Snehota, 1995). These elements are equally important and mutually inter-dependent. Actors are defined by the activities they perform and the resources they control; they are connected to other actors via resources and activities. Each actor's unique combination of resources and activities constitutes its identity. This is known as the Actors-Resources-Activities (ARA) model.

In the ARA model, a relationship is developed as two companies build up activity links, resource ties, and actor bonds. These constitute the substance of business relationships (Håkansson and Snehota, 1995). Through relationships the knowledge of resources can be confronted and adapted in different ways. Activities can be linked to allow better co-ordination, and each actor can change their perceptions of each other and better interpret the situations of individual actors. An example can be a relationship where the activity links are relatively weak while bonds between actors and resource ties are strong. The three layers are not independent; there is interplay between them. The existence of bonds between actors is a prerequisite for them actively to develop activity links and resource ties. Actor bonds can take a variety of forms, including technical, planning, knowledge, socio-economic, and legal bonds. Actor bonds are important since they influence how two actors perceive each other.

Activities in two companies can be linked technically, administratively, or commercially. Resource ties connect various resource elements, such as technology, material, knowledge, and other intangibles. An important point is that a relationship is itself a resource (Ford *et al*, 2003; Håkansson and Snehota, 1995). Relationships between actors represent valuable bridges as they give one actor access to the resources of another. Through relationships it is possible for individual actors to mobilise resources.

Figure 10 shows the relationships among the three layers at three levels of analysis. The first level is the level of a single actor (a firm or a segment of a firm). The second level of analysis is the dyadic relationship between two actors. The third level is the business network. Håkansson and Snehota (1995) consider actors, resources and activities at the network level, regarding these as activity patterns, resource constellations and webs of actors. "Every relationship has the network function; activity links are important in the activity pattern, resource ties in the resource constellation and actor bonds in the web of actors" (p. 39).

According to Håkansson and Snehota (*ibid.*), the advantage of the third level of analysis is to identify where and what effects are likely to occur as a relationship is established, developed or is interrupted, and to identify the factors that affect the possibility of the development of a relationship (p. 44). Further, by adopting a network perspective it is possible to analyse indirect relationships, or the effect on third parties and from third parties. An indirect relationship refers to the relationship between two parties that are not directly related, but which is mediated by a third party with which they both have relationships.

Figure 10. Activities, Actors and Resources Versus Level of Analysis

	Company	Relationship	Network
Activities	Activity structure ↔	Activity links ↔	Activity pattern
		↕	
Actors	Organisational structure ↔	Actor bonds ↔	Web of actors
		↕	
Resources	Resource collection ↔	Resource ties ↔	Resource constellation

Source: Håkansson, H. and Snehota, I (1995) *Developing Relationships in Business Networks*, International Thomson Business Press, London. P 45.

Contemplating the actor, resource, and activity model, Anderson *et al* (1994) conceptualise a number of constructs that capture the connectedness of a focal relationship. A positive effect of the connectedness on decisions and activity of a focal firm in a dyadic relationship is related to anticipated resource transferability, anticipated activity complementarity, and actor-relationship generalisability (*ibid.*). Resource transferability comprises of both aspects of the use of knowledge and solutions from other relations, and use of created knowledge or solutions in other relations. Activity complementarity consists of positive scale effects and positive qualitative effects. Actor-relationship generalisability refers to the positive broader implication of co-operation with a certain actor for other actors.

In summary, 'connectedness' is a core concept in the industrial network approach. A network approach allows a move from dyadic analysis to examination of the impacts of indirect relationships on individual relationships. Resource ties, activity links, and actor bonds are the substance of relationships. In addition, resources are not specific to the firm, but can be acquired through interaction with other firms in the network. Relationships make it possible to access and mobilise the resources of other parties in the network.

3.3. Supply Chains, Supply Networks or Industrial Networks?

The supply chain has emerged in recent years as a salient inter-organisational management concept. Whereas the focus in supply chain management used to be predominantly on the integration of production processes across customer and supplier boundaries, the contemporary focus is as much on integration of innovation processes.

The emergence of supply chain management has undoubtedly assisted industrial developments towards various forms of relationship and partnership strategy. However, it is both conceptually and practically flawed (Lamming *et al*, 2000b). One reason is that it assumes that companies engage in a simple linear vertical 'line' of tiered relationships with suppliers and customers. This may well be very useful for identifying, for example, bottlenecks in critical chains of supply. However, according to a network perspective the model is an over-simplification of the reality of the structure of business-to-business relationships which is much more complex, often involving horizontal, diagonal relationships (e.g. companies engaging in supplier associations). In addition, the image of a 'tiered' structure, largely based on observations from Japanese automotive networks directed by powerful vehicle manufacturers (Cox, 1996; Lonsdale, 2001), leads to the false assumption that suppliers are organised in a logical hierarchy; in reality so-called 'third tier' suppliers may deliver through a layer of tiers for one material, but deliver straight to the OEM (Original Equipment Manufacturer) for another, by-passing several tiers thus technically being a 'first tier' supplier (*ibid*). This problem is at least as pronounced in the recent concept of value stream management, which has been advocated by a group of researchers who developed the concept of lean production (e.g. Hines *et al*, 2000; Womack and Jones, 1996; Diamanescu *et al*, 1997).[33]

Another limitation of the concept of supply chain management is that the term 'management' implies that one party is the manager and the other party the one being managed. Thus, exploiting its sovereign power (Lukes, 1974; Dahl, 1961) one company is perceived to delegate and 'tier' the 'supply chain', and force all the other 'managed' firms to cease determining their own destinies at the expense of some form of joint destiny. This argument, however, makes little sense if one recognises the inter-connectedness of business relationships, as most suppliers have several different customers, which may pull them in different directions.[34] There may be significant advantages for a company in aligning its activities and resources with those of key suppliers and customers, but the ultimate concern of any individual company is its own profitability and destiny.

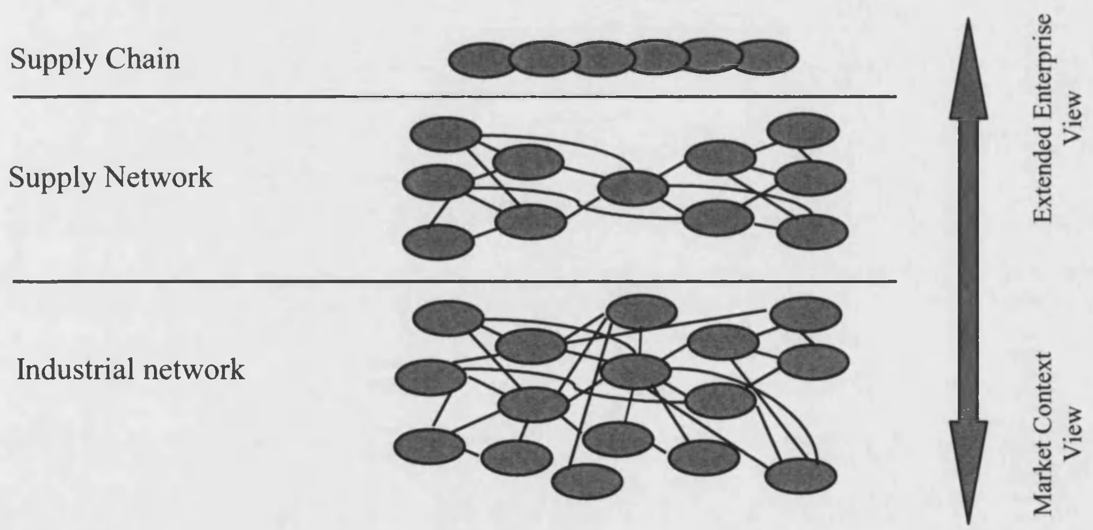
Recently, the concept of *supply networks* has emerged in an attempt to address the conceptual limitations of the supply chain and to provide a wider and more strategic view of supply (e.g. Harland, 1996; Johnsen *et al*, 2000). The term supply networks refers to the set of supply chains involved in the production and supply of a particular product or product family, but the concept also seeks to incorporate links between, or across, individual supply chains. The term 'network' is used to include the inter-connections of individual relationships and chains and to provide a more holistic picture of the system and process of supply (Harland, 1996). Although based more firmly on an IMP perspective, Gadde and Håkansson (2001) appear to be embracing the term supply networks in a similar vein.

[33] Even if the concept, tools and techniques of value stream management arguably have helped to advance the management of industrial customer-supplier relationships across several 'tiers' through practices such as value transparency, value stream mapping, and supplier development.

[34] Not all suppliers have more than one key customer, however, most companies recognise the dangers of too high dependency on one customer. These dangers were only recently illustrated by the dissolved relationship between Mark & Spencer and their long-term, but suddenly terminated, supplier, William Baird (Harrison, 2004).

The term adopted in this thesis is neither supply chain nor supply network, but *industrial network* (Johanson, 1989).[35] This is firstly because it seeks to capture those activities which take place between companies that are wider than those focused on supply, notably activities such as the development of new products, processes, and technologies, and their commercialisation or marketing. Secondly, 'industrial network' is adopted as it has been developed to provide a better understanding of how customer and supplier markets are connected through long-term industrial relationships rather than something 'out there', the 'factor market' assumption of traditional economics (and early industrial marketing) (see Barney, 1986). The concept of industrial networks is associated with a 'networks as markets', or context, view as opposed to a 'network as organisations' or 'extended enterprise' view (see also Lamming *et al*, 2000b). Figure 11 shows the interpretation of the differences in terminology according to the dimensions discussed here.

Figure 11. Supply Chains, Supply Networks, and Industrial Networks



In this thesis the term industrial network is used to refer to the complex context provided by the inter-connectedness of multiple relationships, including both vertical customer and supplier relationships and horizontal relationships e.g. with indirect suppliers or competitors. However, the primary focus is on vertical collaboration taking place within customer-supplier relationships, which are conditioned by a myriad of other relationships. The term 'industrial network' has been favoured instead of

[35] As explained earlier my use of networks is a 'level two' focus: focal firm networks.

'business network'. It provides a more explicit link to an industrial setting and thus excludes actors that are not connected specifically to industrial activities. As discussed in Section 3.2.1 it is recognised, however, that the question of deciding on inclusion and exclusion of network actors is inherently problematic (Cova *et al*, 1998).

3.4. The Role of the Network as Constraint and Enabler of Innovation

Whereas the supply chain model largely ignores the problem of inter-connected customers and suppliers, and individual actors lacking a position of sovereign power, the IMP model of networks focuses on and conceptualises the 'connectedness' of individual actors and their activities and resources. This connectedness implies that what happens in one relationship affects both positively and negatively, what happens in other relationships within the network (Cook and Emerson, 1978; Blankenburg and Johanson, 1990; Ritter, 1999). Some examples of positive effects may be reference, duplication, and combination effects. Examples of negative effects may be hindrance and competition effects (Ritter, *ibid.*). Every relationship has this network function; it serves to connect activity links to the activity pattern, resource ties to the resource constellation, and actor bonds to the web of actors. For example, through the network function change in the activities of any one relationship affects the overall activity pattern.[36]

The implication of the network function is that any actor, and any dyadic relationship, within a network is affected by the actions of other direct and indirect actors and thus has to cope with these (Håkansson and Snehota, 1995). For individual actors pursuing innovation, this implies that the process of innovation is both enabled and constrained by the network in which it is embedded (Håkansson, 1987).

3.4.1. Network as Constraint

The notion that networks may constrain the behaviour and actions of actors embedded in networks is by no means new. Research on social networks and contagion (social influence) has traditionally worked on the assumption that individual behaviour is constrained or even determined by network position (Nohria, 1992). In resource dependency theory (one of the precursors of IMP network theory) this view is also central (Pfeffer and Salancik, 1978; Heide, 1994). Burt (1983) has argued that such constraints even operate at industry level, for example, when an industry in which a firm is embedded is itself embedded in a larger network of inputs and outputs, thus giving some firms less autonomy than others because of cross-industry dependencies. Traditional research on networks thus emphasised the behavioural constraints of actors being embedded in networks, and to some extent depicted individual actors, whether individual or organisational, in a passive role (Galaskiewicz, 1996).

This thesis focuses on two important ways in which networks serve as constraints to innovation, both potentially leading to loss of control over technologies and competencies, some of which may be regarded as 'core'. These two ways can be described as 'increased dependency' and 'risk of dissipation of knowledge'.

The Problem of Dependency: Core or Network Competencies?

The first way in which the management of collaboration activities is constrained by networks concerns dependency, as increased collaboration suggests increased dependency on collaboration parties. Dependency implies that companies lose an element of control over the management of their business and potentially their strategic direction. From an innovation perspective, it implies that companies lose an element of control over the management of their product innovation projects, as they may become dependent on, for example, the product and process technology of other companies (Ford and Saren, 2001). Fundamentally, the problems of dependency and control can be seen as closely related to the question of what companies should develop and make in-house (and thus control) and what they should buy in - or source – externally; in strategy terms this becomes a matter of the defining the core competence of the organisation (e.g. Prahalad and Hamel, 1990).

The notion of the different forms of network dependency is not easily compatible with a core competency (Prahalad and Hamel, 1990) or a resource-based view of the firm (e.g. Penrose, 1959/1995; Wernerfeldt, 1984). The resource-based view regards the firm as a collection of heterogeneous resources, which provide the source of sustained

[36] An example that may be easy to relate to would be the dependence of a married couple on other family members and friends. These may be very positive, for example in financial terms. Conversely they may also be detrimental, for example, due to emotional interference.

competitive advantage. As such resources need to be of superior value, due to ownership of, or access to, valuable, rare, non-imitable, and non-substitutable resources (Barney, 1991). Barney has argued that non-imitability, or imperfect imitability, may be achieved if resources are characterised by three factors: historical dependence, causal ambiguity, and social complexity. Hence, according to the resource-based view resources that are socially complex and knowledge-based and have a strong tacit dimension may be difficult for competitors to copy (Peteraf, 1990; Winter, 1987). Therefore, firms rely on and protect their heterogeneous and unique resources to generate sustained competitive advantage, deploying what Rumelt has termed 'isolating mechanisms' (1987). Companies can be expected to be seeking to nurture and develop such resources internally, leaving those that are 'non-core' to be developed and supplied by external companies (Quinn and Hilmer, 1994; Quinn, 1999).

The paradox of developing innovations within networks is that the more companies collaborate with other companies, the less independent they become. To put it differently, they effectively lose control over their technologies, some of which they may regard as 'core'. This implies that core competencies and technologies ultimately become vested in relationships rather than within the firm. The risk of such an approach is that companies may become hollow rather than truly networked or 'virtual' (Chesbrough and Teece, 1996). From a network perspective, however, a core competency strategy does not imply that companies should only rely on external companies for non-core resources. In debating multi-technology corporations, Granstrand *et al* (1997) have shed some light on this management problem and argued that multi-technology corporations need to have distributed rather than distinctive core competencies. In their view "the challenge for management is to give more attention to the distribution of corporate technological competencies beyond the core, the enhancement and integration of new competencies, and the potential for related new product markets..... While the emphasis in production has been on increasing focus and out-sourcing, large firms have at the same time been spreading their technological competencies beyond their distinctive core. These competencies include the capacity to improve and to co-ordinate change in complex production systems and supply chains as well as to explore and exploit emerging new technologies" (pp. 15-16).[37] Hence, Granstrand *et al*'s view (1997) implies that the management of the critical network relationships that form part of and add value to core competencies and core technologies becomes pivotal. Thus a collaborative approach is required and the ability to manage the collaboration within complex networks potentially becomes critical: it becomes a matter of network (or *networking*) competence (Ritter, 1999).

In summary, the literature indicates that companies that seek to concentrate on their core competencies are likely to become increasingly dependent on the resources, competencies and technologies developed and supplied by or with other companies. The problem of dependency is therefore genuine in a world, which has seen more and more companies out-source what they previously considered to be 'core' to their own business (Quinn, 1999; Granstrand *et al*, 1997). The next section discusses different forms of dependency that can be identified through the literature.

Types of Dependency

Håkansson (1987) identified four common types of dependency that may obstruct innovation: technical dependencies, knowledge dependencies, social dependencies, and logistic or administrative dependencies. These four types of dependency may each have a negative bearing on innovation if they do not pre-exist or if they are not developed along with the innovation.[38] These four types will now be discussed in turn, commencing with technical dependency.

Technical dependency is a central problem of innovation management because products consist of, and incorporate, bundles of different forms of technology (Ford and Saren, 2001). Customers do not buy technologies *per se* but the benefits of those technologies as applied in a specific product/service offering. As discussed earlier, technologies may be product technologies, such as ABS brake systems in cars, or process technologies, such as EDI (Electronic Data Interchange) purchasing systems. As the example of EDI indicates, such technology often does not reside within companies but between them; they are used to facilitate activity links, resource ties, and actor bonds and they are exploited through these network connections. Indeed, a technology has no value in

[37] Granstrand *et al* (1997) make the important distinction between the diversification and distribution of products and technologies: their concept applies to the latter.

[38] Cousins (2002) offers a comparable typology of inter-organisational dependencies, distinguishing historic, economic, technological, and political dependencies. Historic dependency is similar to path dependency discussed later in this section; economic dependency is more unclear but appears to be related to a 'commercial' dependency; technological dependency is similar to Håkansson's technical

itself, it is only valuable when related to other network actors (*ibid.*). In the context of systemic innovation technical dependency may be particularly important (Chesbrough and Teece, 1996). Technological innovations, such as Apple computers and Beta videos (Rosenbloom and Cusumano, 1987), illustrate this point. Both were apparently superior in terms of technological performance, however, they failed to succeed because they were dependent on a series of other innovations which ultimately did not take place. Technical dependency, however, is not merely present at the level of systemic innovation. It is present also within incremental product development projects. As companies are increasingly outsourcing technologies that they consider to be non-core, technical and technological dependency increases (Ford and Saren, 2001). Companies are relying on external companies to develop, manage and supply technology, which increasingly comes in bundles that form part of complex system offerings (Granstrand *et al*, 1997; Gadde and Jellbo, 2002). There are now signs that such system, or modular, offerings have begun to change the structure of industrial networks across a range of sectors, with large system suppliers taking on more responsibility on behalf of assemblers (Baldwin and Clark, 1997; Doran, 2003). The implication of such industrial network restructuring change processes is that individual actors become more dependent on other actors in order to perform their own activities. Consequently individual actors lose their ability to control technologies and technology applications in-house; this implies that they are constrained in their actions and activities and therefore ability to manage the innovation process.

Knowledge dependencies are closely related to technical dependencies, particularly if one perceives technology as incorporating knowledge elements as well as physical artefacts (Ford and Saren, 2001). Individual actors are dependent upon the knowledge, capabilities, and competencies of other direct and indirect network actors. Indeed such knowledge include not only explicit but also tacit knowledge (Nonaka and Takeuchi, 1995). The relatively recent endorsement of the relevance of learning in networks (Powell *et al*, 1996), network learning (Knight, 2002; Håkansson and Johansson, 2001), and even learning networks (Bessant and Tsekouras, 2000), indicates the importance of knowledge exchange and inter-organisational learning.[39] Such arrangements reflect

dependency; political dependency is of particular relevance to government organisations where there may be obligations for example to source from domestic suppliers.

[39] The publication by Bessant and Tsekouras reports findings from Project ION, of which the author was a member. In Project ION 'learning networks' were conceived as groups of actors coming together simply to learn e.g. about a new manufacturing process or technology.

attempts to share, capture and formalise both explicit and tacit knowledge through, for example, directed experiment and reflection. The implication of such networked knowledge exchange and learning, however, is that individual actors become more dependent on other actors and their knowledge in order to perform their own activities. Individual actors become constrained in their actions and activities; they are unable to manage and control the direction of the innovation process independently.

Social dependencies matter because, as Nohria (1992) has argued, all organisations and networks are socially embedded, and social interaction facilitates the development of good personal relationships. Indeed, socialising and social networking are often seen as ways to obtain important 'know-who' information (Gadde and Håkansson, 2001; Blau, 1964). Uzzi (1997) has proposed that socially embedded relationships have three important features: trust, fine-grained information transfer and joint problem-solving arrangements. Granovetter (1973, 1985) has shown how weak, often informal, ties may provide conduits to important information. Thus, social networking may facilitate business and innovation processes. Grandori and Soda (1995) have discussed social co-ordination and control as a mechanism to obtain stable relationships based on group norms, reputation, and peer control. This implies that the social part of business relationships provides the trust and long-term stability, which can help to prevent opportunistic behaviour (Johanson and Mattsson, 1987). The long-term stability provided by social dependencies means, however, that social dependencies present a constraint on innovation because relationships and networks may be difficult to break into for new actors (Håkansson, 1987) and they may be difficult to dissolve.

Logistic and/or administrative dependencies are important to bring innovations to market in an effective and efficient manner. They also create problems for the management and control of new product development processes and the direction of technological innovation. Håkansson (1987) refers to an example of a bolt manufacturer, which was introducing a new range of bolt products. He discovered that despite the superior technical features of the new bolts the manufacturer's efforts failed because it could not cope with the requirements of internationally dispersed after-market operators. Indeed, the trend towards internationalisation and global networks (e.g. Dicken, 2003) can be expected to make administrative and logistical dependencies even more important. Despite this, there is little evidence of research in the network literature that has attempted to examine this form of network dependency.

In addition to the four types of dependency suggested by Håkansson (1987) and examined over the previous three pages, 'path dependence' has been employed as a concept in economic history and historical sociology literatures to explain sequences of events and patterns of evolution within economic structures, including industrial networks (Araujo and Harrison, 2002). This concept is examined in more depth in the following as the final form of dependency considered as part of this literature review.

In classic economics, history was hardly given any serious attention; economic theory was static in its lack of recognition of past actions.[40] In basic terms path dependence implies that future action is dependent on past actions i.e. history matters. However, it is a complex concept, which has been defined by David (1985, p. 332) as: "A path dependent sequence of economic changes is one of which important influences upon the eventual outcome can be exerted by temporally remote events, including happenings dominated by chance elements rather than systematic forces. Stochastic processes like that do not converge automatically to a fixed-point distribution of outcomes, and are called non-ergodic."

Thus, path dependence is a property of sequences of events, steeped in history and therefore influencing the present and the future; it creates friction (Håkansson and Waluszewski, 2002). Path dependent processes also combine general processes with elements of chance, making them inherently unpredictable (Araujo and Harrison, 2002). Path dependence implies an 'out-of-phaseness' between the operation of causal mechanisms and effects (Sayer, 2000, p. 15). Current events and actions bear the imprint of past events and actions through the operation of social and material structures that act as the 'carriers of history' (Araujo and Harrison, 2002). Cause (or causal mechanisms to use Sayer's critical realist term) and effect are distant in time and space.[41]

[40] As indeed were the models of strategic planning that dominated the late 1970s and 1980s e.g. Porter (1980, 1985).
[41] We return to Sayer's Realism in Chapter Five.

Research on industrial networks has also shown how path dependence can explain stability and change processes of technological systems (Lundgren, 1995; Håkansson and Lundgren, 1997; Håkansson and Waluszewski, 2002). Longitudinal case studies have shown that path dependence implies a constraint on future options. Path dependence implies that events follow a path or trajectory and that the ordering in which events happen affects their sequence and temporal unfolding (Tilly, 1994). The path implies that future decisions and actions are constrained although they are not predetermined or fatal. We may choose to alter a historical path by breaking with the path, jumping on another path, or shaping a new one. In contrast, all our actions are past dependent. A useful analogy may be that of a large ship on an ocean, which often needs several miles to change its path but can do so if it must. So *path* dependence is not the same as *past* dependence.

Path dependence may constrain what can be done within dyadic relationships. Actors invest in relationships over long periods of time and it becomes both difficult and costly to terminate existing relationships in favour of new ones; relationships become a burden or 'resource heavy' (Håkansson and Snehota, 1998; Ford and Håkansson, 2002). Moreover, path dependence affects whole technological systems (e.g. Lundgren, 1995; Håkansson and Lundgren, 1997). As Araujo and Harrison (2002) point out, historical sociologists and economic historians often focus on conjunctures arising from the temporal intersection of different trajectories. As discussed in Chapter Two innovations that are discontinuous or disruptive (Linton, 2002) often involve companies shifting from one technological path or learning curve to a more attractive one (Dosi, 1982; Nelson and Winter, 1977). Firms may decide to jump on a trajectory created by bandwagon effects and pursue the 'technological corridor' (Georghiou *et al*, 1986) offered by the trajectory. Hence, paths and trajectories impact on the past, present and future.

The different forms of network dependencies can be summarised as presented in Table 5.[42]

[42] The different forms of dependency may be present at not only network but also dyadic level (although these two are arguably problematic to separate as dyadic relationships are embedded in networks). This inquiry is specifically concerned with dependency at the network level. For example, there can be technical dependency within a dyadic relationship, which affects a product development project. However, as the dyad is part of a wider network the technical dependency may not be purely within the dyadic relationships but ultimately within the network.

Table 5. Forms of Dependency in Industrial networks

	Definition	Themes & Trends	Authors
Technical/ Technological dependency	Focal actors depend on bundles of different forms of technology available within and through network connections: product, process and marketing technology	System sourcing and modular development make manufacturers increasingly dependent on (system) suppliers	Håkansson (1987) Granstrand et al (1997) Baldwin and Clark (1997) Ford and Saren (2001) Gadde & Jellbo (2002) Cousins (2002) Doran (2003)
Knowledge dependency	Focal actors depend on different forms of knowledge available within and through network connections: e.g. tacit and explicit	Networks of learning and networked learning facilitate knowledge exchange and capture	Håkansson (1987) Nonaka and Takeuchi (1995) Knight (2002) Håkansson and Johanson (2001) Bessant and Tsekouras (2000)
Administrative/ Logistic dependency	Focal actors depend on administrative and logistical requirements and practices of other network actors	Increasing internationalisation of industrial networks may amplify problem of administrative/logistic dependency	Håkansson (1987)
Social dependency	Focal actors depend on social business relationships; these may be difficult to break into and dissolve	Social networking and trust	Granovetter (1973; 1985) Håkansson (1987) Nohria (1992) Grandori and Soda (1995) Uzzi (1997) Gadde and Håkansson (2001)
Path dependency	Property of sequences of events, steeped in history and therefore influencing the present and the future. Actions of focal actors depend on past actions	Patterns of innovation follow technological trajectories. Inter-organisational relationships are resource-heavy	David (1985) Lundgren (1995) Araujo and Harrison (2002) Håkansson and Waluszewski (2002)

Risk of Dissipation of Information and Knowledge

The second way in which networks may serve as constraints on innovation concerns the dissipation of information and knowledge, which can happen through inter-connected relationships. Valuable knowledge may be lost to third parties, including competitors, for instance, through common suppliers. Firms are faced with the dilemma that on the one hand they wish to learn from their partners yet at the same time retain their own core proprietary assets and thus prevent leakage of crucial know-how (Kale *et al*, 2000). This may constrain the process of collaboration by limiting, for example, the extent of information and knowledge transferred and shared within partnerships. The interaction of different bodies of knowledge, which generates innovation in the first place would thus be hindered. This may be particularly important as companies increasingly compete on knowledge and competencies (Prahalad and Hamel, 1990; Nonaka and Takeuchi, 1995) as they risk losing their competitive advantage.

Companies in industries such as pharmaceuticals or biotechnology, where technology provides the competitive advantage, and where industrial espionage is not uncommon, are often concerned about the protection of proprietary knowledge. As illustrated by the recent problems of music producers in retaining copyright in the face of Internet piracy copies, patents and other legal means of protection are often imperfect in protecting against imitations. This is particularly so in regimes of 'weak appropriability' (Teece, 1986; 1998), where intellectual property systems provide limited legal barriers to imitation (e.g. in electronics), and knowledge is codified or explicit rather than tacit and thus relatively easy to replicate. In comparison, the appropriability regime in the pharmaceutical sector is often strong, as patents provide effective legal means against imitation and are difficult to 'invent around' (Teece, 1998). Teece suggests that product technology is much more difficult to protect because unlike process technology firms must expose these in order to profit from the technology. Mansfield *et al* (1981) found that approximately 60 per cent of patented innovations was imitated within four years. In a later study, Mansfield (1985) found that information concerning product and process development decisions was generally in the hands of several rivals within 12 to 18 months (Teece, 1986). Other industries are also exposed to these risks, possibly mostly those that possess some forms of 'unique' and innovative technologies (Lamming *et al*, 2000a). For example, Dyson, the vacuum cleaner manufacturer, is very cautious about collaboration with external parties for innovation and has patented every single piece of its technology to protect it from being copied by competitors (Muranka and Rootes, 1996). This is consistent with recent research seeking to classify different types of supply network, which highlighted how companies supplying 'innovative and unique' products were reluctant to share information with suppliers. This was the case in two pharmaceuticals, one electronics and one telecommunications case (Lamming *et al*, *ibid.*) i.e. all high-tech industries but in different intellectual property regimes.

Bower and Keogh (1997) focused on the risks innovative, technology-based firms run when working closely together with clients (customers) and suppliers in terms of losing their competitive edge through knowledge or know-how transfer to potential competitors. As emphasised by Bower and Keogh these risks arose as a result of the necessity for firms involved in close collaborations to transfer whatever tacit and formal knowledge was required for the relationship to be successful. One of their findings was that technology leader firms in the oil and gas industry limited their contributions when they were obliged to enter into close partnerships where there was a potential for knowledge flows to exceed what they deemed desirable, thereby creating barriers to innovation within those alliances. Bower and Whittaker (1993) and Bower and Keogh (1997) observed that many of these dangers were not recognised by the firms involved. They concluded that firms sharing leading-edge technology might act in ways detrimental to the industrial network as a whole (and therefore also themselves) if they perceived there to be any conflicts of interest.

Trust would appear to be an important factor in preventing loss of knowledge through network connections (Gulati, 1995; Bradach and Eccles, 1989; Ring and Van de Ven, 1992; Madhok, 1995). Indeed the function of trust is to prevent the opportunistic behaviour associated with leakage of information and knowledge (Gulati, 1995; Bradach and Eccles, 1989; Ring and Van de Ven, 1992; Madhok, 1995). Dyer and Nobeoka report how Toyota has mastered the balancing act of motivating network 'members' to participate and openly share valuable knowledge whilst preventing undesirable spillovers to competitors (2000). They found that members of Toyota's network were encouraged to share their knowledge with everybody else within the network: proprietary knowledge was defined not at the level of the individual company but at the level of the network. Whereas this to some extent seems to ignore the overlap between different networks, it does implicitly emphasise the need for a strong segregation of knowledge belonging to different networks. Ford *et al* (2003) refer to 'Chinese walls' as a metaphor for understanding such divisions of knowledge.[43] The demands on trust thus become ever critical to facilitate the sharing and protection of network knowledge (e.g. Gulati, 1995; Sako, 1992; Håkansson and Snehota, 1995).

The risks of dissipation of sensitive valuable knowledge through networks pose a problem for companies. In a very direct sense, they can lose control over knowledge and technology to competitors. Such risks can be conceived of as a negative consequence of networks. Any company's attempts to manage the innovation process may thereby be constrained by networks.

[43] Ford *et al* (2002) refer to Neville Pawsey, Blue Windmill Consultants, for the idea of 'Chinese walls'.

3.4.2. Network as Enabler

The previous section discussed how networks may constrain the actions and activities of network actors. However, the implications of the network function are dual, and therefore positive effects also can be derived. In other words, researchers have begun to focus on networks not only as constraints but also as opportunity structures (Galaskiewicz, 1996). It is important to distinguish between two network enabling issues. The first is the opposite or flip side of the network constraint issues discussed in the previous section. An example of this is that dyadic technical dependency is directly associated with a positive network effect. To put it more succinctly, companies collaborate to gain technical knowledge and specialised capabilities from collaboration parties. The second network enabling issue is what companies *do* to exploit the network. This is concerned with their strategies for coping with network constraints and capitalising on the resources, activities, and actors available through the network. Although these two issues may be difficult to distinguish in practice, this inquiry focuses specifically on the second issue as this is where there seems to be a lack of existing research. This section therefore identifies and discusses different approaches and strategies that appear to be prevalent amongst companies across a variety of industries.

Within social network research Granovetter (1985) argued that a social network should be viewed as a form of social capital, or an asset, which an actor can use to further its own interests. Granovetter's concept of the strength of weak ties (1973, 1985) indicates that strong resource connections in networks have to be complemented by a set of weak, often informal, ties, as each of these is likely to provide a conduit to important information. Indeed weak ties may prove to be strong as they are the ones that an individual actor does not normally exploit (Granovetter, 1973). The recent trend towards 'networking' in a business context (Harland *et al*, 2003) may signify a recognition of the value of gaining access to and exploiting such relationships or ties through networks.

The exploitation of networks is relevant not only at the individual or personal level but also at the company level. For example, Bower's analysis (1993) showed how a small group of biotechnology and pharmaceutical companies deployed a pool of critical resources through a wide network through extensive networking. Similarly, in his analysis of a joint R&D project between ASEA and Nybo, set up to develop a new steel production process, Laage-Helman (1987) showed how the success of the project was an outcome of Nybo's interaction with several other organisations, both direct and indirect. The interaction, or networking, in such reported cases seemed to be of an emergent nature rather than following any organised planned pattern. Nevertheless, the benefits of networking in such cases are evident. It should be emphasised, however, that the concept of networking can be perceived in different ways. For example, in Ford *et al*'s recent conceptualisation of 'networking' (2003), networking captures not only positive but also negative effects of networks i.e. both as a way exploiting and coping.

One of the criticisms of the IMP research on networks is that it has predominantly focused on the negative constraining implications of networks. Within the IMP group there seems to be an implicit assumption that networks imply a 'muddling-through' approach to management and strategy (Mintzberg, 1992), whereby actors can only cope. Valla (1998) has argued that recent industrial changes demonstrate a capacity for purposive action of individual actors in networks. However, he does not believe that IMP research has yet responded to the challenge. In a similar vein Harland and Wensley (1996) have described the IMP approach as 'strategy leaf kicking', arguing that the network approach is based on a Mintzbergian assumption that other companies will dictate the extent to which any one network actor is free to decide its own destiny. The positive effects of networks, whereby they can be used to advance and enable the actions of individual network actors, have traditionally been under-emphasised in the IMP network research, although very recently it appears to be gaining increasing attention (e.g. Ford *et al*, 2003).

There is an evolving body of research, describing case examples of firms that have been argued to have managed their networks and achieved some form of competitive advantage (Harland *et al*, 2003). Benetton (Jarillo and Stevenson, 1991), Toyota (Womack *et al*, 1990), and Nissan (Nishiguchi, 1994) are examples of such accounts. The practices described by these authors appear to present an organised and pro-active approach to managing in networks.

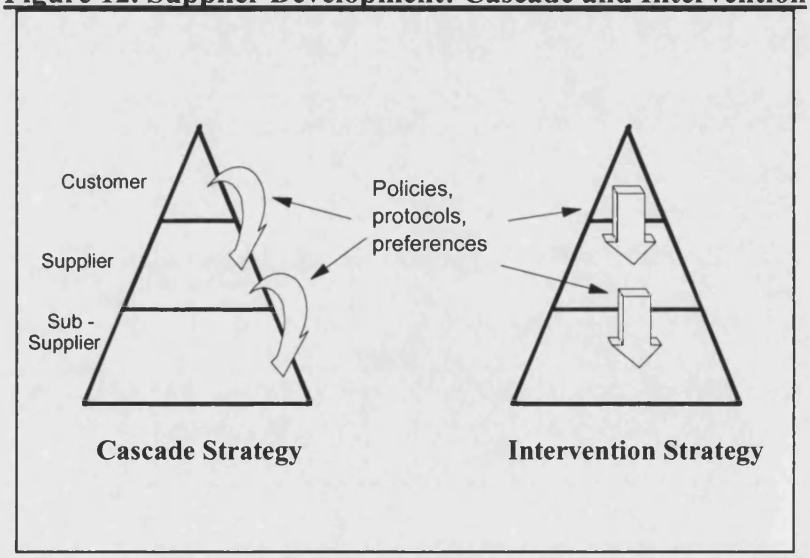
The studies by Takeuchi and Nonaka (1986) and Imai *et al* (1985) suggested that whole networks were committed to a 'lead manufacturer', such as Fuji-Xerox. Although acknowledging that these networks have emerged in a self-organising manner in Japan during the post-war economic boom and gathered around lead manufacturers plants, the authors described how suppliers were divided into so-called 'primary' and 'secondary' subcontractors, equivalent to what has also been termed first and second tier suppliers (Nishiguchi, 1994). According to their study it was this detailed division of labour and tasks, which gave the innovation process more momentum. For example, subcontractors were able to respond very quickly to special requests and adapt to changes in the environment. Whether or not the division of work was indeed a process of rational design may be questionable; from a network perspective it seems likely that historical and cultural factors may at least partly explain how the industries studied have evolved into so-called tiered network structures (see for example Pascale, 1990).

The IMVP study (Womack *et al*, 1990) elaborated on the division and co-ordination of work in automotive supply chains. Womack *et al* described how lean Japanese car assemblers assigned the design and development of whole modules to a group of first tier suppliers who in turn usually utilised a team of second tier suppliers, conducting the detailed development and engineering. However, within lean Japanese car assemblers not only groups of suppliers at different tiers were involved in the process; car dealers also played an important role. They formed an integral part of the whole production system and even the development team, providing frequent customer information. As a consequence they had elaborate knowledge about the products they sold which in turn meant that they were in a strong position to feed into the development process. The findings by Womack *et al* (1990) thus indicated that lean car assemblers benefited significantly from delegating and co-ordinating responsibilities in their supply networks. Lorenzoni and Baden-Fuller (1995) and Jarillo (1988) have reported similar findings involving a range of firms in different industries, including Apple, Benetton, Corning, McDonald's, Nike, Nintendo, Sun, and Toyota. When compared with many IMP findings on networks (e.g. Håkansson and Snehota, 1995), one may question the extent to which these findings are a result of different network perceptions or pictures (Ford *et al*, 2003) or indeed whether the reasons for different results are ontological (as will be discussed in Chapter Five). Consistently with much supply chain management research, these studies tend to assume the presence and leadership of a powerful hub at the 'centre' of the network.

Dyer and Nobeoka's (2000) analysis of Toyota's knowledge-sharing network can be seen as belonging to the same body of research. Their recent work, however, offers an arguably more realistic account of the 'Toyota's network', highlighting that effective and efficient knowledge-sharing networks do not have a large controlling 'hub' at their centre, with suppliers being committed purely to the 'hub'. Rather, even Toyota's network can be seen as one of multi-lateral relationships of which Toyota is not the sole disseminator of knowledge. All actors both disseminate and absorb knowledge gained through and with other actors.

Recently, research on networking within different types of supply network has indicated four broad strategies of managing in supply networks. These are cascade, intervention, vertical two-way development, and network development respectively (Lamming, 1996; Lamming *et al*, 2000b; Johnsen, 2000). In this body of work these four strategies have been applied specifically to the process of supplier (or *supply*) development. Although based on a supply perspective, they may provide a useful point of departure for distinguishing strategies for drawing on networks during technological innovation. Figure 12 illustrates the logic of the first two strategies when originally applied to the problem of supplier development:

Figure 12. Supplier Development: Cascade and Intervention



Source: Adapted from Lamming, R.C., Johnsen, T, Harland, C.M. and Zheng, J (2000) Managing in Supply Networks: Cascade and Intervention, 9th International Annual IPSERA Conference, University of Western Ontario, Canada, p. 404.

The cascade strategy describes the imposition of initiatives and performance requirements from the customer to the supplier, and thence to sub-suppliers (Lamming *et al*, 2000b). It offers a strategy for drawing on several layers of suppliers and sub-suppliers; it is based on the assumption that customers have a simple supply chain logically divided into 'tiers'. The customer firm, often a large OEM, perceives that its power may be cascaded throughout its supply base. The cascade strategy is often most strongly exemplified as a corporate supplier development scheme. The fundamental assumption is that the ideas and practices that flow from the customer, or the 'top', are naturally good. It has been suggested that this assumption is derived from the old cornerstone of marketing that the customer is 'king' (*ibid.*). At its basic level cascading is a way for a customer to delegate responsibility to its suppliers; in practice, it has been contended that it often takes the form of a more imposing style of leadership (*ibid.*).

The 'intervention' strategy is similar to the cascade strategy but entails the customer directly becoming involved in its indirect supplier's activities (e.g. 'second tier' suppliers) and thereby effectively converting an indirect relationship into a direct one. It may be applied in cases where the customer seeks to help out an ailing supplier, applying its management skills to operational problems (Hines, 1996). It has been argued, however, that it may also be practised because the customer does not trust the supplier, for example, to implement operational improvements itself. The customer therefore engages directly in the supplier's activities to ensure proper implementation. This direct involvement is suggested by the straight arrows in Figure 12 (Lamming *et al*, 2000b), however, logically the connection is arguably directly with sub-suppliers.

The cascade and intervention strategies may be useful in this thesis for depicting different strategies for drawing on networks. However, as suggested by Lamming (1996) and Lamming *et al* (2000b) the problem with both strategies is that they assume that customers hold a position of knowledge and operational superiority, and hence sovereign power (Lukes, 1974; Caldwell, 2003). Consequently, Lamming *et al* (2000b) conceptualised two alternative theoretical models that fits within the concept of lean supply. These were named 'vertical, two-way development' and 'network development'. Data from Project ION cases provided early indications that such approaches may be forming in practice, although the concepts remain loosely defined.

Thus, it has been suggested that some large and powerful companies manage a (focal firm) network of direct and indirect relationships (e.g. Womack et al, 1990; Dyer and Nobeoka, 2000; Imai *et al*, 1985; Lamming *et al*, 2000b). It is unclear, however, whether these companies operate in a particular set of circumstances, which allows them to exercise a high degree of control of their supplier network, and hence manage part of it very effectively. Also, even if the circumstances exist to enable this type of strategy, it is unclear whether it is always appropriate for firms to try to exert control over their network through different network strategies.

An assumption of the IMP work is that actors cannot manage or control their network; they can merely *cope* (e.g. Håkansson and Snehota, 1995). From a critical point of view, however, this assumption may be seen as rather conservative given the accounts of powerful companies discussed in this section, which appear to manage, or at least *convene* effectively within the network (Lamming *et al*, 2000b). Using the term 'orchestration', Möller and Svahn make a similar argument (2003). The important issue, however, may be more about the benefits of attempted 'network management' than whether or not it is achievable. Recently, Ford and Håkansson (2002) proposed a set of network paradoxes, one of which was that the more a company attempts to control the network in which it is enmeshed, the less effective the network may in fact be. This argument can also be logically extended to apply to the management of innovation in networks, as successful innovation is often characterised more by chaos than control (see for example Nonaka, 1988). However, it is contrary to current supply chain management practice, which appears to have influenced how companies manage process innovation initiatives, such as supplier development.

3.5. Conclusions

Chapter Three set out to examine the concept of interaction between industrial customers and suppliers. The examination has highlighted the significance of understanding the nature of the *interaction process* and the factors that impact upon it, including the elements and process of interaction, the participants, and the atmosphere and environment in which the interaction takes place. From the perspective of understanding how the process of innovation involves external actors (individuals and organisations), an understanding of the interaction process and the consequences of an interaction perspective is pivotal. A substantial body of research is emerging, which examines how manufacturers (generally assemblers) can involve their suppliers in the product and process development. From an interaction perspective this can be seen as assuming an active customer but a rather passive supplier that simply responds to the customer's 'supplier management'. There is a lack of current research which adopts a true interaction perspective on the process of technological innovation.

It has been discussed that interaction may extend to 'collaboration' or 'co-operation' in which relationships are likely to be high involvement, mutual, sharing, reciprocal, and have elements of goal and value compatibility. Collaborative relationships are also long-term and require significant effort and investment (Huemer, 1998). The definition and use of the term 'collaboration' in this thesis is inclusive rather than exclusive: it assumes that most relationships have collaborative elements and that it is a matter of degree of collaboration rather than either/or.

Another major conclusion of Chapter Three is that although an interaction perspective helps to understand how companies relate to and do business with each other, it is inadequate unless it is combined with a network perspective. A network perspective takes the interaction perspective one step further by emphasising the need to understand the *embeddedness* of individual dyadic relationships in wider networks. Hence, a dyadic relationship is affected by other relationships that are directly or indirectly connected to the dyad. It is through this network that innovations are managed and can be exploited.

Interaction implies that network actors have to cope with the behaviour and actions of other network actors, but at the same time they can influence the behaviour and actions of others. Such a view contrasts with the assumption present in the dominant model of modern strategic management, the resource-based view (e.g. Wernerfeldt, 1984), that companies develop and nurture their own unique and distinctive resources and competencies internally and need to protect these from other organisations (e.g. Rumelt, 1987). Ford *et al* (2003) refer to this view as 'the myth of completeness' because it leads to the myth that companies are complete organisations in their own right able to operate on the basis of their own resources and competencies. In contrast, the network perspective assumes that resources, competencies and technologies are developed and deployed through networks. Companies are relying on external companies to develop, manage and supply technology, which increasingly comes in bundles that form part of complex system offerings (Granstrand *et al*, 1997; Gadde and Jellbo, 2002).

The consequence of an interactive network perspective on innovation is that the process of innovation and thus product development is both enabled and constrained by other network actors and their activities and resources. Research on networks from across different schools of thought has sought to describe and conceptualise these enabling and constraining effects (e.g. Håkansson, 1987).

The literature has revealed that the process of innovation may be constrained as a result of actors operating in networks. Two main forms of such constraints have been discussed. The first concerns 'dependency effects': when companies collaborate with external companies they become dependent upon them. Five main forms of dependence have been identified and discussed: technical or technological, administrative or logistic, path, knowledge, and social dependencies. The second network constraint concerns the risk of dissipation of information and knowledge. Both are seen as potentially critical problems as more and more companies choose to collaborate. The IMP interaction and network approach has contributed much to advancing the knowledge of these network constraints. However, a criticism of the IMP research is that it has focused predominantly on the negative, constraining, side of networks (e.g. Valla, 1998; Harland and Wensley, 1996). This criticism is focused on the tendency to almost portray individual actors as passive recipients of the behaviour and actions of other network actors.

Conversely, the literature has revealed that networks may enable the process of innovation. The importance of distinguishing between two network enabling issues has been emphasised. The first is the flip side of the network constraint issues at the dyadic level. For example, although technical dependency is a negative network effect it is directly associated with a positive effect as companies collaborate to gain technical knowledge and specialised capabilities from the collaboration parties. The second network enabling issue is what companies *do* to exploit the network. This concerns their approaches to, or strategies for, coping with network constraints and capitalising on the resources, activities and actors available through the network. Although the two issues may be problematic to distinguish in practice, this inquiry focuses specifically on the second issue as this is where there seems to be a lack of existing research.

An emerging body of research focuses on what companies can do to exploit the positive side of networks. The theory of supply chain management assumes a very active role and behaviour of individual network actors, albeit predominantly those that occupy a powerful customer position. Thus, it can be regarded as a way to act in a purposive or intentional fashion (Valla, 1998). Two strategies for managing or convening actors, resources and activities in the wider network were subsequently identified and discussed: cascade and intervention. The drawback of these is that they are based upon the supply chain management assumption of a linear model of the structure of business relationships into vertical hierarchies, which ignores the complexities and constraining consequences of networks.

Hence, the outcome of Chapter Three has been an understanding of the process of interaction in business relationships and the implications of an interaction and network view. The next step is to try to conceptualise how the process of managing collaborative innovation in networks is constrained and/or enabled by the innovating actors being embedded in networks. It is this that will be the focus in Chapter Four.

CHAPTER FOUR: A CONCEPTUAL FRAMEWORK

4.0. Introduction

The discussions so far centre on the need to understand the process of innovation as one of interaction in complex industrial networks. Chapter Three culminated by examining the implications of networks on the management of innovation, and identified different forms of enabling and constraining network effects as discussed in the literature. Chapter Four follows on from this theme and presents the conceptual framework of the thesis. This provides a way of thinking about the process of managing collaborative innovation in networks and potential constraining and enabling network effects on specific innovation management processes. The conceptual framework presented here has underpinned the empirical investigations conducted as part of the thesis. It has been developed from the literature review and undergone iterations following the exploratory mini-survey and the pilot case study.

The chapter commences with an explanation of how a set of collaborative innovation activities was developed. These form the core of the conceptual framework. Each activity is subsequently examined one by one, drawing on literature that justifies their inclusion. This part of Chapter Four includes a review of literature which has not been examined already in Chapter Three. It therefore continues the literature review but focuses specifically on developing a set of collaboration activities for inclusion in the conceptual framework and has thus been included in this chapter. Next, the conceptualisation of the different forms of network effects is presented. This conceptualisation is based on the examination of network effects presented in the previous chapter, but explains the specific interpretation and use of the concepts in this thesis. The conceptual framework is then presented and the chapter concludes by outlining the emerging research questions, which guided the case studies.

4.1. Developing a Set of Key Activities of Managing Collaborative Innovation

4.1.1. The Initial Set of Activities

The set of activities has evolved and been refined throughout the project. An initial set of activities was constructed on the basis of the literature review. This set is shown in Table 6:

Table 6. Initial Set of Activities

Activity	Definition
Identifying/Selecting	The process of identifying actors, including selection criteria
Mobilising	The process of motivating actors to commit to project, including arranging sharing of risks and benefits
Synchronising	The process of adapting activities and resources, including procedures, processes and systems
Informing	The process of informing other actors of e.g. concepts, technical specifications, procedures and performance feedback
Assigning Human Resources	The process of assigning (on long-term basis) staff to development projects e.g. resident design engineers
Co-ordinating	The process of adjusting and adapting activities within network
Timing	The process of deciding the moment or stage of involving actors in the project

The initial set of activities was used for the exploratory mini-survey and was refined following further literature review. ‘Identifying/selecting’ was replaced by ‘uniting’ as the exploratory mini-survey, together with the further literature review, indicated that actors in some cases were not simply identifying and selecting other actors in a rational fashion. Rather, in some cases they were at least as much subjected to *being* identified and selected. The two activities of ‘informing’ and ‘assigning human resources’ were substituted with, respectively, ‘communicating’ and ‘exchanging human resources’ for the same reason. ‘Co-ordinating’ was removed from the set as it became to be seen as an element of all activities. Instead it was included in ‘network effects’, as will be explained in Section 4.3. and thus it was unnecessary to include it as a separate activity.

The pilot case included ‘knowledge exchange’ as a separate activity from ‘communicating’. However, these two activities proved to be overlapping and thus difficult to distinguish. 'Knowledge exchange' was replaced with 'problem solving', which emerged as an important activity in the pilot case and subsequently also found support in the literature (as discussed in the following section).

4.1.2. The Eventual Set of Activities

The set of collaboration activities that emerged from the exploratory exercises resulted in a set of activities which is presented in this section. The activities form the core of the conceptual framework and reflect ways in which individual companies manage innovation projects vis-à-vis other actors and are thus relationship and interaction orientated but firm-specific. Table 7 provides a brief definition of each activity.

Table 7. Collaboration Activity Set

Activity	Definition
Uniting	The process of identifying actors, including selection criteria – or being identified/selected
Mobilising	The process of motivating actors to commit to project, including establishing ground rules and objectives and arranging sharing of risks and benefits
Synchronising	The process of mutually adapting activities and resources, including development procedures; aligning objectives and technology roadmaps
Communicating	The process of exchanging e.g. design ideas, concepts, technical specifications, policies, procedures and performance information
Problem Solving	The process of resolving e.g. technical or manufacturing/supply problems
Exchanging Human Resources	The process of allocating (on long-term mutual basis) staff to development projects e.g. resident design engineers
Timing	The process of deciding the moment or stage of involving actors in the project

The following section discusses each of the activities as presented in Table 7.

Uniting

Much research has emphasised the need for thorough systematic processes for identifying and selecting appropriate suppliers in new product development projects (e.g. Handfield *et al*, 1999). There is substantial empirical evidence to suggest that selecting the right suppliers and customers is an appropriate starting point for any innovation venture (e.g. Handfield *et al*, 1999; Bruce *et al*, 1995; Littler *et al*, 1995).

However, the view associated with such research implies a non-interactive view of customer-supplier relationship development, as the customer is supposed to merely select a group of passive suppliers. The concept of 'uniting' used in this thesis emphasises that the identification and selection process is often interactive. To put it differently, a company may not decide alone with whom it wants to work; instead its desires to choose its preferred partners may be conditioned by other actors' identification and selection processes.

Von Hippel's seminal research (1976, 1985, 1986, 1988) indicated the dominant role of so-called 'lead users' in idea generation. His research highlighted the importance of identifying those customers who face particularly demanding needs before the bulk of the market place. These users would hence be in a position to facilitate novel innovation where 'normal' customers would be inappropriate. Von Hippel's research was originally based on a survey focused on scientific instruments but his studies are now endorsed by a large number of empirical studies (e.g. Foxall and Tierney, 1984; Shaw, 1985; Biemans, 1989; Voss, 1985; Parkinson, 1982). Further, Håkansson's research (1987; 1989) has conceptualised and provided further empirical evidence for this stream of research. Håkansson stressed the interactive nature of the process, although this was also a feature of Von Hippel's research as the process was seen as 'user-initiated'. However, the normative message concerning the management of novel innovation projects was for suppliers to identify the lead users and involve them in product concept development (Herstatt and Von Hippel, 1992). The research by Biemans (1995) was akin to the research on lead users, although concerned more generally with integrating customers in the process of innovation. By studying 17 case studies of medical equipment innovations in the Netherlands, he also highlighted the importance of 'partner selection' as a key activity.

Håkansson and Eriksson (1993) also stressed the importance of selecting suitable partners. Based on the findings from 123 Swedish SMEs having 'important co-operative relationships' (Håkansson, 1989) and two illustrative case studies, they presented four key issues, or co-ordination activities, for "getting innovations out of supplier networks". These related to combining and integrating different supplier relationships, the first of these being 'prioritising'. According to their definition this included the selection of suitable partners and criteria to consider when choosing partners. The authors specified that not only technical competence matters, but also how well the supplier is connected with other actors in the field. Compared with the lead user focused research, Håkansson and Eriksson's work was undertaken specifically from the perspective of customers. Their work has since been continued not least by Wynstra's extensive empirical research involving 20 cross-industry case studies in Sweden and the Netherlands and building on a prior survey of 500 Scandinavian customer-supplier relationships (1998).

More recently Oliver *et al* (1999) examined a set of key processes of managing multi-party alliances, through an exploratory survey of 26 'innovation networks' and six case studies focusing on automotive and biotechnology networks. These 'innovation networks' consisted of buyer-supplier relationships and horizontal relationships when aiming to develop new products or technologies. One of the key processes included was what they coined 'network creation', defined as partner selection/assembly and the original raison d'être of the network. Overall, the research discussed in this section supports the inclusion of the assembly, or uniting, of the key actors in the network as a critical starting point for any innovation project.

Mobilising

The second activity is what can be termed 'mobilising'. It is closely related to uniting as it concerns 'getting actors involved'. However, it concerns more specifically motivational issues, including establishing ground rules and objectives, and developing incentives for key actors.

The importance of mobilising as a core activity for involving key actors in innovation projects has been maintained first of all by the supplier-orientated research by Håkansson and Eriksson (1993) and Wynstra (1998). These authors defined mobilising as getting support from or engaging suppliers in the development project. Biemans' research (1995) complemented their research by stressing the need for identifying and motivating the right person(s) and formulating clear-cut agreements. This included explicit clarification of the basis of the collaboration (division of tasks, link with responsibilities, reasons for entering the partnership, goals, project life, contributions, divisions of costs and benefits etc.).

The findings from the IMVP (Womack *et al*, 1990) on the process of product and production development in lean Japanese car assemblers, which concerned many of the same issues as the earlier studies by Takeuchi and Nonaka (1986) and Imai *et al* (1985) to some extent underpinned the findings of Håkansson and Eriksson (1993) and Biemans (1995). These, however, were conducted on a more international basis (including Japanese companies). Their very substantial empirical results pointed to the significance of establishing a basic contract to ensure the long-term commitment of the parties and to establish the ground rules for determining prices and quality assurance, order and delivery, proprietary rights and materials supply, making the parties work together to mutual benefit, and enabling sensitive information and knowledge to be exchanged (relating to the activity of communicating which shall be discussed later). This body of research is complemented by Littler *et al*'s work (1995), which examined the key success factors for collaborative new product development in 106 UK firms. Amongst a variety of other success factors they concluded that establishing partnership equity, and ensuring that parties contribute as expected, are key to partner motivation and commitment. This is further supported by the study by Ragatz *et al* (1997) involving 60 companies which pointed to formalised risk and reward sharing agreements and joint agreement on performance measures, amongst other factors. The research by Oliver *et al* (1999) substantiated these findings. Their findings from six case studies, three automotive networks and three bio-medical networks, identified the critical role of risk and benefit sharing and motivation.[44]

There is thus substantial empirical evidence to suggest that mobilising is a critical activity for involving key actors in innovation projects. Existing research has emphasised specifically the establishment of ground rules and arrangements for sharing of risks, benefits, and objectives. These factors appear to be crucial for the development of trust and commitment between innovating companies.

Synchronising

The third key activity is synchronising. This is first of all emphasised in the research by Håkansson and Eriksson (1993), and is defined as the mutual adaptation of activities and resources. This has since been further investigated and refined in Wynstra's research (1998). In recent years Brennan and Turnbull (1997) have identified and discussed different forms of adaptation in buyer-supplier relationships, such as product,

[44] They suggested that a variety of contingencies shape how activities are discharged. The authors have initially identified that the degree of routinisation, the presence or absence of a key 'system architect' and the stage of the development process all appear to be major explanations of different models of network structure and process.

production process, production planning, and organisational structure, further specifying that these can be classified according to degrees of formality and scale. They also highlighted that adaptation can be made by the customer and/or the supplier. Their work built on an extensive body of research developed not least by Turnbull and Valla (1986) and Ford (1980), linking adaptation to commitment over the course of different relationship development stages. When compared with adaptation it appears that synchronising is different in that it implies a more mutual orientation. From an innovation project perspective it might include the synchronisation of project objectives or milestones, and potentially also the alignment of more long-term strategic objectives.

Håkansson (1989) and Ford and Saren (2001) stressed the need for companies to align the technological developments and strategies of network actors. Handfield *et al* (1999) emphasised that one of the cornerstones of effective supplier involvement in product development is the sharing and alignment of technology roadmaps, which describe the performance, cost, and technology characteristics of future products each company plans to develop and introduce over a given time span. They describe how such behaviour may even become institutionalised when the actors meet regularly to share roadmaps. In summary, synchronising appears to be crucial for the development of commitment.

Communicating

The fourth core activity is communicating. This may not be surprising as good communication is often seen as the key to good networking. Internal and external communication has been studied in its own right as one of the success factors of innovation (e.g. Ancona and Caldwell, 1990). There is substantial empirical evidence to maintain that it is critical to collaborative innovation.

Wynstra (1998) and Håkansson and Eriksson (1993) included 'informing' as one of a small set of key activities, which companies can apply to improve innovation performance. Wynstra defined this as "acquiring and sharing information internally as well as externally" (p 121). The term 'informing', however, implies that this is from the perspective of a customer company informing its suppliers rather than *vice versa*. In other words, the focus is on one-way communication and arguably a slightly static view of the process. The research by Håkansson and Eriksson (*ibid*) and Wynstra (*ibid*), although conceptually and empirically extensive, is largely based on Swedish and Dutch case studies.

Communication, not least in terms of sharing knowledge, was also central to the research by Takeuchi and Nonaka (1986) and Imai *et al* (1985), discussed in Chapter Three. Studying a small number of cases of successful Japanese product development efforts, in terms of speed and flexibility of development, they described how members of supplier networks reached out across functional boundaries and shared risk, responsibility, and information. The 'lead manufacturer' and its suppliers exchanged substantial information and the authors also observed extensive lateral/horizontal information exchange between suppliers at the same tier. These suppliers tended to share information more freely, including leading edge information and suggestions as to possible improvements to existing products as well as new product ideas. Vertically the ties were stronger and much direct exchange of information took place. The findings by Womack *et al* (1990) further emphasised how the basic contracts (discussed under 'mobilising' and thus showing a link between these two activities) made it possible for manufacturers and suppliers to exchange even sensitive information and knowledge. This included, for example, mutually establishing prices, analysing costs, and the supplier openly disclosing each step of its production process, including cost, quality, and technology details. Through this process the two parties jointly sought ways to cut costs and improve quality. Focusing on the cost aspect, Lamming (1993) later conceptualised this as 'cost transparency', although emphasising that true cost transparency involves two-way disclosure of cost and value information as opposed to one-way 'open book' negotiations, which tends to imply that the supplier's books are disclosed but not the customer's (Lamming *et al*, 2001). Such openness and transparency of communication has been linked to the development of trust. Helper's (1990) voice strategy, which she suggested as a better alternative to an 'exit strategy', was based not least upon the development of communication systems, facilitating a rich flow of information. Using Ghoshal and Bartlett's (1988) three innovation stages, sensing (the development of ideas), response (development of product and processes), and implementation (exploitation - production, distribution etc.), Lindquist (1996) found that limited geographical distances were an advantage during the response stage in developing trust through face to face communication and thereby reducing cost.[45]

From a more specific new product development perspective, Littler *et al*'s work (1995) examined the key success factors for collaborative new product development in 106 UK firms. They also found, amongst a variety of other success factors, that frequent inter-company communication increased the likelihood of success. The study by Ragatz *et al* (1997) involving 60 companies supplemented those findings, identifying direct, cross-functional, inter-company communication as the most widely used technique for integration. They also found that common barriers are the sharing of proprietary information and the 'not-invented-here' syndrome. This was recently corroborated by Oliver *et al*'s (1999) study, which highlighted the importance of information processing and knowledge capture, and by McGloin and Grant (1998) and Ballou *et al* (2000) who suggested that open and effective information exchange is a prerequisite for successful relationships. Open communication thus seems to be a salient factor in creating trust and commitment between collaborating actors.

Problem Solving

The fifth key activity is problem solving. Integrated problem solving was a central message in Clark and Fujimoto's study (1991). In a similar vein Lamming (1993; 1996) highlighted the importance of a joint approach to problem solving in (primarily process) innovation. Based on his automotive research, which was part of the IMVP project (Womack *et al*, 1990), Lamming identified that one of the crucial problems in many customer-supplier relationships was the tendency to blame the supplier whenever a problem arose. He argued that lean Japanese automotive companies took a much more mutual and problem-orientated approach, seeking jointly to identify the root cause of problem symptoms, and thereby remove a significant amount of waste.[46] Such an approach to problem solving has since become one of the core elements of the concept of lean supply (Lamming, *ibid.*), although not universally acknowledged as a core technique of lean product development (Karlsson and Åhlström, 1996). Takeishi (2001) recently reported that auto-makers' problem solving process with suppliers had a significant effect on component design capability.

[45] During the sensing and implementation stages, access to large, diverse quantities of information was crucial, internationally as well as nationally, but less broad and more focused during the response stage, thus giving the process an 'hour-glass' shape.
[46] Ishikawa (or fishbone) diagrams provide a well-known tool for the practise of root cause analysis.

The ability to solve problems on a joint basis has further been emphasised by McGloin and Grant (1998) and Sako *et al* (1994). Sako *et al* (*ibid.*) pointed out the role of solving problems between suppliers and customers, and identified that "an increasing proportion of UK suppliers said that their customers would help them to match a competitor's effort" (*ibid.* p. 240) Similarly, as discussed earlier Helper (1990) advocated a 'voice' strategy as an alternative to an 'exit' strategy, where the customer works with the original supplier until the problem is resolved (the exit strategy secures a supplier's compliance by use of a credible threat to terminate the relationship).[47] Naudé and Buttle (2000) and Mohr and Spekman (1994) also linked problem solving to customer-supplier relationship quality.

Achrol (1991) linked conflict resolution to the development of trust through three structural mechanisms: shared information systems, interlocking directorates, and executive exchanges/rotation. The author identified that trust is enhanced by mutual satisfactory conflict resolution through the interaction process. Oliver *et al*'s research (1999) later identified conflict resolution as a key process for managing innovation networks. The importance of developing mechanisms was emphasised, as these can help to overcome the conflicts as quickly as possible. Problem solving therefore appears to be a key factor in the development of mutual trust.

Exchanging human resources

The sixth key activity is exchanging human resources. The findings from the IMVP (Womack *et al*, 1990) and Takeuchi and Nonaka (1986) and Imai *et al* (1985) emphasised the role and importance of assignment of teams of resident design engineers to car development teams. As shown by Clark and Fujimoto (1991), such co-operation may enable not only manufacturing process improvements, but also product development.

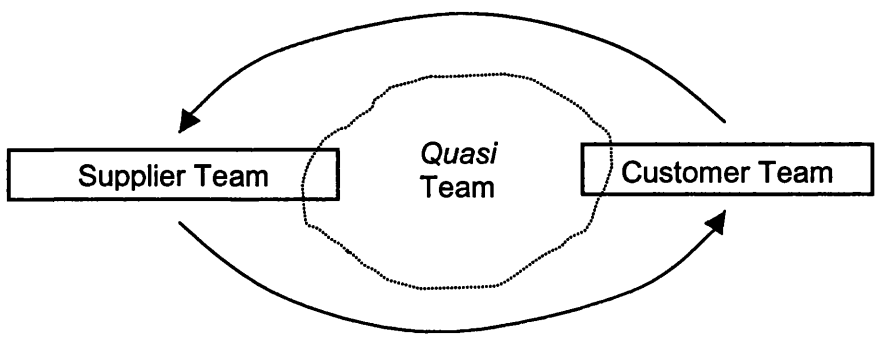
The usefulness of exchange of human resources was also identified by Dyer's (1996) research regarding supplier networks. This study revealed that tightly integrated and spatially condensed production networks, with high levels of co-specialised human resources, outperformed more loosely integrated production networks with low levels of inter-firm specialisation. He later continued and refined this work (see for example Dyer and Nobeoka, 2000) focusing on the practise of *shukko* (inter-firm employee transfer) in

[47] Helper used Hirschman's earlier concepts of exit, voice and loyalty (1970).

Japan as a means to create a network identity.[48] Based on Japanese experiences in supplier development, Hines (1996) discussed the wide use in Japan of both permanent and temporary exchange of staff such as 'business group integration', 'employee release', and loaning of staff during periods of labour shortage.

The literature examining human resource exchange often adopts a non-interactive perspective, whereby the focus is on one party allocating staff to the other party. Using the concept of the quasi-firm (Blois, 1972), Lamming (1993) suggested that a more interactive understanding of the process may be obtained by viewing the relationship as an entity that takes on an identity of its own and should be managed as such. Consequently, staff can be allocated to the relationship from both sides for development purposes. Adapting this idea to human resource exchange this idea can be depicted as below:

Figure 13. Interactive Human Resource Exchange



The interaction perspective conceptualised here suggests that the project development team is viewed as a 'stand-alone' team, which neither exists within the customer or the supplier, but in between.

Timing

The final, but perhaps fundamental activity, is timing. In other words, the timing of all the other activities, including the moment of involvement of partners (Wynstra, 1998). Håkansson and Eriksson (1993) distinguished between timing of involvement within a single company (between various functions and projects), the timing within a

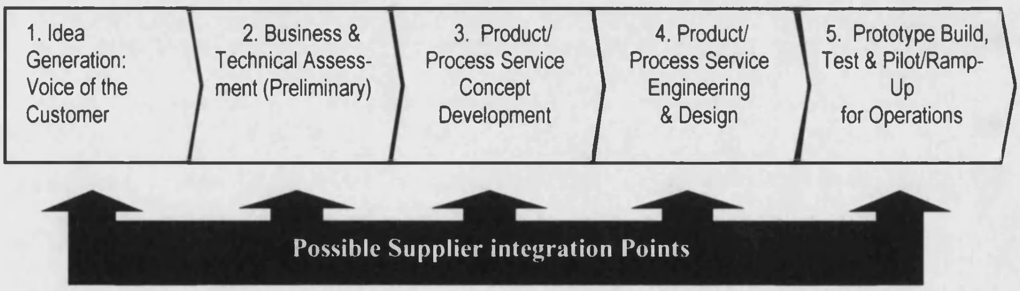
[48] They reported how Toyota annually transfers app. 120-130 individuals to other firms in the 'value chain', mostly suppliers. Such transfers are both permanent and temporal.

relationship (the co-ordination of the two parties' activities over time), and the timing of the relationships in relation to each other (network).

The literature on supplier involvement in product development tends to assume a sequential stage model, sometimes including overlapping stages (see the earlier section on the product development process), where suppliers can become involved at different stages of the process. This is illustrated in Figure 14.

Since the 1980s the normative emphasis has been on early involvement of suppliers, for example providing a role for key suppliers in preliminary technical assessment and specifications. Handfield *et al* (1999) argued that as much as 80 per cent of total product cost is committed or 'locked-in' during the concept and design stages. Therefore, decisions made early in the design process have a significant impact on the resulting product quality, cost, and cycle time. Furthermore, it becomes increasingly difficult and costly to make design changes as the process moves on. Thus, as much technical expertise needs to be brought in as soon as possible (p. 63). As Figure 14 shows, Handfield and his colleagues (*ibid.*) argued that suppliers of strategic importance (high involvement) should be involved early on in the process, whereas suppliers of less strategic importance (low involvement) should be involved later in the process.

Figure 14. Product Development Stages and Supplier Involvement



- Suppliers of complex items
- Suppliers of systems or subsystems
- Suppliers of critical items or technologies
- Strategic alliance suppliers
- 'Black box' suppliers

- Suppliers of simpler items
- Suppliers of single components
- Suppliers of less critical items or technologies
- Non-allied suppliers
- 'White box' suppliers

Source: Based on Handfield, R. B., Ragatz, G. L., Petersen, K. J., Monczka, R. M. (1999) Involving suppliers in new product development, *California Management Review*, Vol. 42, No. 1, Fall, p. 62.

From an international cross-industry sample of 134 companies, Handfield *et al* (*ibid.*) found that 23.1 per cent of companies approached involved suppliers at idea generation, 22.3 per cent at preliminary assessment, 37.2 per cent at concept development, 14.9 per cent at engineering and design, and 2.5 per cent at prototyping/ramp-up.[49] Overall, the findings indicated that 'supplier integration' in product development projects had been 'fairly successful'. Nevertheless, over 45 per cent of their respondents stated that they were not satisfied the results of their supplier integration efforts. Handfield and his colleagues pointed to the lack of companies' experience of how to implement supplier involvement as one cause of this negative result.

Early supplier involvement was a prominent feature of Takeuchi and Nonaka's research (1986) discussed earlier. In their five case studies, suppliers were invited to join the project team in the early phases of the project to develop or test some parts, delegating authority to trusted suppliers. These in turn were able to realise a learning curve effect even for bench models through 'learning in arrangement', as numerous companies ordered bench models with different shapes and sizes, but many of the orders required the same production technology and skill. Certain suppliers were also said to specialise in prototype production.

Bonaccorsi and Lipparini's later work (1994) on strategic partnerships in new product development placed particular emphasis on the importance of early supplier involvement. They distinguished three models of supplier involvement in product development. The first of these is the traditional model where the full range of suppliers, or an approved vendor list, was requested to quote a price and offer full technical and commercial conditions against technical specifications. Secondly, the Japanese model where suppliers became involved already at the concept stage before product design. Thirdly, the advanced model where a group of preferred suppliers was requested to invest in early development work to provide technical solutions and demonstrate with simulations, drawings, and computer printouts, the performance of component, parts, or systems (see also Birou and Fawcett, 1994). In this last model supplier selection took place relatively late as all suppliers were invited to invest in development work even though only one of them would win. The authors called this a 'partnership' model, although the benefit of the relationship seemed to be mostly for the manufacturer and the winning supplier. The importance of their model is that it

[49] Although it was an international sample, 68 per cent of the responses came from North American companies. The companies had a median of six years experience of involving suppliers in new product development.

emphasised the timing of involvement and indicated that different activities may be performed differently at different stages of the innovation project.

There is thus a large emphasis on early supplier involvement in current research. However, as pointed out by Wynstra (1998), the assumption that 'the earlier the better' is of questionable value as the role of the supplier during the very early stages may be problematic. The recent findings by Møller (2002) endorsed this view. In his case studies involving the Danish hi-fi manufacturer Bang & Olufsen and its suppliers, he found that the iterative rather than sequential progress made early supplier involvement difficult. It was difficult for suppliers to relate to the highly dynamic characteristics of the very early stages where design specifications and goals are highly fluid. Møller's findings suggested that suppliers encounter difficulties in relating to the highly abstract language being used during the conceptual stages, including subjective and tacit specifications that are difficult to translate into a language that the supplier can interpret. In fact, he argued that early involvement of suppliers is such a resource demanding activity that it may be impossible for many companies to cope with it, and hence not reap the benefits of early supplier involvement.[50] This may provide some explanation for the negative findings on the benefits of early supplier involvement by Birou (1994), Hartley (1994) and Hartley *et al* (1997). Møller's results (2002) also suggested the limitations of a project specific view, as some suppliers may be involved across several development projects through general R&D involvement. These findings correlated with Wynstra's (1998) acknowledgement of the limitations of a development project as the unit of analysis, and Lamming's conceptualisation of lean supply in which customer and suppliers collaborate on a continuous basis, sharing a common search and selection environment (Lamming, 1993; Nelson and Winter, 1977), and aligning policies and strategies. Overall, these recent results pointed to the appropriateness of 'timely' rather than early involvement. Timing thus seems to be a suitable construct for capturing the process of deciding the moment of involvement.

Table 8 provides an overview of the key activities, their background and empirical support.

[50] The suggestion by Møller concerning specification problems in early supplier involvement was complemented by Karlsson and Åhlström (1996) who reported difficulties in suppliers providing detailed cost estimates during early supplier involvement.

Table 8. Literature Support for Set of Key Activities

ACTIVITY	THEMES	REFERENCE
Uniting	• Prioritising: selection of suppliers and level of intensity of involvement • Partner selection criteria e.g. knowledge, willingness to co-operate, market position, confidentiality • Specification of lead user indicators and identification process • Network creation: assembly of network parties • Systematic supplier selection process	• Håkansson & Eriksson (1993); Håkansson (1989); Wynstra (1998) • Bruce *et al* (1995); Littler *et al* (1995); Biemans (1995) • Von Hippel (1976, 1985, 1986, 1988) Herstatt & Von Hippel (1992) • Oliver *et al* (1999) • Handfield *et al* (1999), Monczka *et al* (2000)
Mobilising	• Mobilising: getting support from or engaging suppliers, motivating • Motivating and risk & benefit sharing with suppliers • Establishing ground rules and ensuring equality is key to motivating and commitment	• Håkansson & Eriksson (1993); Håkansson (1989); Wynstra (1998) • Oliver *et al* (1999); Womack *et al* (1990) • Bruce *et al* (1995); Littler *et al* (1995); Biemans (1995)
Synchronising	• Synchronising defined as mutual adaptation of activities and resources • Aligning objectives and technology roadmaps	• Håkansson & Eriksson (1993); Håkansson (1989); Wynstra (1998) • Handfield *et al* (1999), Monczka *et al* (2000)
Communicating	• Informing suppliers and sharing information • Importance of communication • Open and extensive information sharing • Problems of proprietary information exchange; knowledge capture • Cost and value transparency	• Wynstra (1998) • Biemans (1995) • Imai *et al*, 1985); Quinn (1985); Takeuchi & Nonaka (1986); Womack *et al* (1990); Monczka *et al* (2000); McGloin and Grant (1998); Ballou *et al* (2000) • Oliver *et al* (1999); Ragatz *et al* (1997) • Lamming *et al* (2001)
Problem solving	• Joint no-blame problem solving: focus on root cause analysis • Problem solving approach helps relationship quality • Conflict resolution mechanisms • 'Voice' as alternative to 'exit' strategy	• Lamming (1993, 1996); McGloin and Grant (1998); Sako *et al* (1994); Monczka *et al* (2002) • Naudé and Buttle (2000) • Oliver *et al* (1999); Achrol (1991) • Helper (1996)
Exchanging human resources	• Shared division of labour - resident design engineers • Give suppliers active role on project team • Benefits of co-specialised human resources • Cross-transfer and loaning of staff	• Womack *et al* (1990) • Monczka *et al* (2000) • Dyer (1996) • Hines (1996)
Timing	• Timing of activities within company, relationship, and network • Benefits of early supplier involvement • Problems of early supplier involvement	• Håkansson & Eriksson (1993); Håkansson (1989) • Wynstra (1998) • Ragatz *et al* (1999); Bonaccorsi & Lipparini (1994) • Møller (2002)

In conclusion, none of the existing sets of activities that have been examined in this section are totally comprehensive and some are somewhat static in focus. Wynstra's evolving model is becoming very comprehensive (see for example Wynstra and Van Echtelt, 2001), although it focuses more specifically on the involvement of purchasing as opposed to external network actors (see also Dowlatshahi, 1992). It is also slightly static in focus, as it does not take into account how a focal company's attempts to manage supplier involvement are conditioned by the wider network.[51] The interactive emphasis is pivotal, as it assumes that one party can only perform activities depending on other actors and their strategies and actions. The interaction perspective also makes it realistic to assume that the same activities apply for the management of upstream as

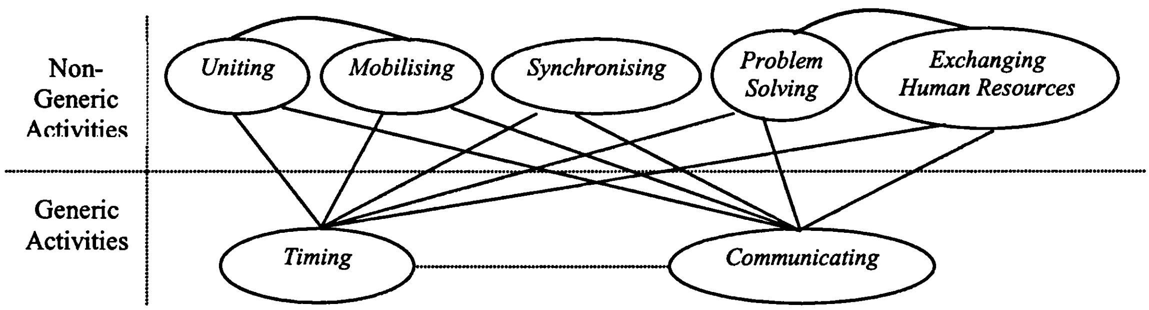
[51] Wynstra's activity 'co-ordinating' seems to represent an attempt to capitalise on network resources, but is arguably only a partial consideration.

well as downstream relationships, as these are essentially the same forms of relationship, customer-supplier relationships, only viewed from different perspectives.

4.2. The Set of Collaboration Activities: Possible Inter-Connections

The activities discussed in the previous section have all been included as part of the set of activities that form the core of the conceptual framework, because each is regarded as important in its own right. Nevertheless, the process of conceptualising a set of collaboration activities always involves a risk of overlapping amongst individual activities. These overlaps are highlighted in this section and illustrated below.

Figure 15. Possible Inter-Connections Amongst Collaboration Activities



As Figure 15 illustrates, communicating and timing are seen as more generic than the other activities, as they to some extent underpin these. As indicated in Section 4.1, there are communication elements of all the non-generic activities. For example, one reason why companies may consider exchanging human resources is that this activity provides a practical mechanism for improving communication during product development projects. Timing is defined as the timing of all the other activities (see also Wynstra, 1998) and is thus similarly generic in nature.

Within the non-generic activities, uniting and mobilising are closely inter-related as mobilising concerns a number of motivational issues that may influence whether or not actors will choose to become involved in a project (Håkansson and Eriksson, 1993). Furthermore, problem solving and exchanging human resources can be seen as being closely inter-related, since the resolution of problems has been identified as a core reason why companies should wish to engage in the exchange of staff (Hines, 1996).

Despite the inter-connections between some of the collaboration activities that have been included in this piece of research, it is believed that each activity, in the light of the existing research evidence discussed in the previous section, is important in the management of collaborative innovation projects. It is held in this thesis that the set of activities is useful for describing and understanding key processes of collaborative innovation management. However, the premise of this thesis is that activities cannot be managed in isolation of other network actors' similar attempts to manage activities in their part of the network. Hence, the control of focal actors on the management of collaborative innovation activities is subject to complex network effects. These are conceptualised in the following section.

4.3. Network Effects on Collaborative Innovation Activities

The premise of this thesis is that a company's innovation activities do not take place within a vacuum but are part of a complex network or pattern of activities that link webs of actors and constellations of resources. Therefore, network connections may serve as enablers of the process of innovation and at the same time may constrain each of those activities. The following section presents the conceptualisation of network effects and relates these specifically to the activities discussed in the previous section.

4.3.1. Network Enablers on Collaboration Activities

Chapter Three identified that networks may affect the process of managing collaborative innovation both positively and negatively. On the positive side, it may be possible for a company, engaged in new product development, to deploy resources and thus technologies within its network, thereby *using* the network as an enabler of innovation. The literature has indicated that this is often managed through a process of what can be broadly described as 'networking' in the sense of using one relationship to gain access to others. Recent work by Ford *et al* (2003) has suggested that networking is a wider concept involving choices related to conforming and/or confronting network relationships, consolidating and/or creating network positions, and conceding and/or coercing in relation to other actors in the network (see also Harland *et al,* 2003).[52] In

[52] A full examination of the implications of these new concepts is beyond the scope of this thesis. However, it is apparent that changes are being made within the IMP group of relationship and network researchers to bridge what was conceptualised in this thesis as a divergence between network co-ordination and networking.

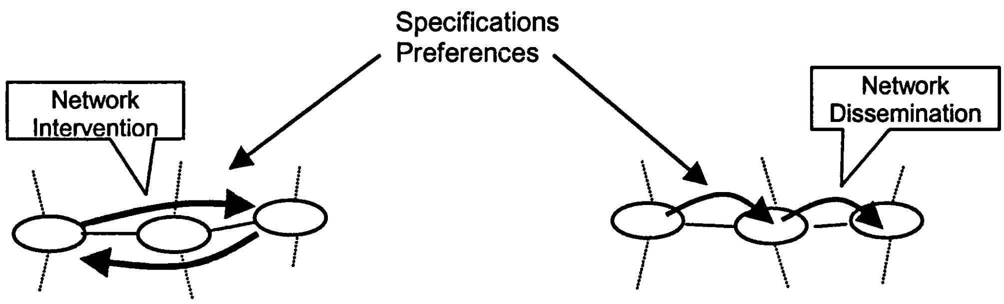
comparison, the reference to and use of the concept of networking in this thesis is more restricted. It reflects a predominantly informal activity of using the network function (network connections) to access indirect network relationships through direct relationships. To avoid any confusion with other interpretations of the concept of networking, the term applied in this thesis to denote such a networking approach is an 'access strategy'.

The access strategy suggested here entails network actors gaining access to, and exploiting, indirect relationships through direct relationships. One example would be accessing an indirect 'second tier' supplier through a direct 'first tier' supplier. The access approach is thus close to the concept of 'interaction' although the focus here is on one actor reaching beyond the dyadic relationship.

In addition to the access approach, research has indicated that it may be possible, at least for relatively powerful companies, to influence how activities are managed in the wider network by means of different network co-ordination strategies. There is evidence to suggest that companies can do more than simply 'network'; they may be able to capitalise on the network by adopting a pro-active approach and co-ordinating and delegating activities amongst individual actors. Håkansson and Eriksson (1993) and Wynstra (1998) discuss co-ordination in a similar vein, although their conceptualisation of co-ordination appears to be more specifically concerned with "the adjustment and adaptation of development activities and resources between suppliers and the manufacturer" (Wynstra, 1998, p. XIII). The conceptualisation of network co-ordination strategies in this thesis is as a way of delegating responsibility and exerting influence beyond direct relationships.

Two network co-ordination strategies were discussed in Chapter Three: cascade and intervention. Here, these two strategies are re-conceptualised for application to the management of collaborative technological innovation in networks. Hence, due to the focus in this thesis on new product development as opposed to supplier development, (process innovation) 'policies, protocols, and preferences' (see Figure 12), have been replaced with 'specifications and preferences'. Moreover, the nature of the intervention strategy has been re-conceptualised, in an attempt to address the problem of the concepts of cascade and intervention as discussed earlier, namely that they are based upon a rather simplistic linear and hierarchical conception of industrial network structures. The re-conceptualisation of network strategies is thus shown below:

Figure 16. Re-Conceptualisation of Network Co-ordination Strategies



Following Figure 16 'network intervention' entails a network actor actively involving itself in an 'indirect' relationship and thereby effectively converting an indirect relationship into a direct one by circumventing a direct supplier to reach an indirect supplier (although not in supply terms). This may be for the purpose of providing, for example, design specifications or sub-supplier preferences (e.g. safety and environmental standards). 'Network dissemination' entails a focal actor instructing another actor to disseminate or forward the focal actor's specifications and preferences; it is a strategy of delegation. It is similar to the cascade strategy, although it does not rely on the arguably restricted interpretation of structured vertical supply chains (see for example Rich and Hines, 1998).[53] As the models illustrate, both the intervention and dissemination strategies may (at least theoretically) work from supplier to customer as well as *vice versa.*

In comparison with the dissemination and intervention strategies, the conceptualisation of the access approach suggests a less imposing style; there is little attempt to seek to influence how other actors manage their relationships. Thus, in the conceptual terms of Ford *et al* (2003) the access strategy may be conceding and consulting rather than assertive and coercive.

[53] The cascade model applied by Rich and Hines (1998) may have its use in particular contexts for particular purposes, such as policy deployment in Japanese or Japanese inspired supplier associations, however, this research indicates the limitations of such a hierarchical model when depicting technological innovation processes in networks.

Table 9 provides an overview of the two conceptualised network co-ordination strategies and the access strategy for enabling collaboration activities within the network:

Table 9. Network Co-ordination

Characteristics	Intervention Strategy	Dissemination Strategy	Access Strategy
Style	Assertive and coercive: seeking to control other actors	Assertive and coercive: seeking to guide other actors	Conceding and consulting: seeking to work with and through other actors
Use of network	Connecting to indirect relationships around direct relationships thus effectively converting these into direct relationships: *action*	Connecting to indirect relationships through direct relationships thus delegating relationship management responsibility: *action*	Connecting through direct relationships to interact with network-wide relationships: *interaction*

4.3.2. Network Constraints on Collaboration Activities

Networks may constrain innovation, because the more companies collaborate with other companies, the less independent they become, so they lose an element of control over their technologies, some of which they may regard as 'core'. The discussions in Chapter Three indicated that ultimately this may imply that technologies become vested in relationships rather than within the company. The literature indicates that companies risk becoming hollow if they fail to manage those critical relationships in an appropriate manner.[54]

This thesis focuses on technical or technological dependence, administrative/logistic dependence, and path dependence. Knowledge is viewed here as a central ingredient of technology and thus seeks to capture knowledge dependencies through technological dependencies rather than as a separate issue; for this reason technological rather than technical dependency is the term used from this point onwards. Social dependency is also not going to be pursued as a separate form of dependency as it is assumed that a focus on social aspects of relationships and networks constitutes a large but somewhat separate area of research, where the unit of analysis is on the individual rather than the organisational level.

Risk of dissipation of knowledge and technology is seen as a potentially critical problem as more and more academic models and theories encourage companies to share not only tactical but also strategic information and knowledge with key collaborators. Network inter-connections can be seen as a problem as they provide conduits through which knowledge and technology may dissipate to network actors, most critically competitors.

The conceptualisation of the dual effects, network constraints and enablers, is shown in Table 10. The two halves (left and right) of the table are not intended to accurately portray the mirror sides of network effects. Hence, the column 'network as enabler' purely identifies the conceptualisations of three different strategies that some companies reportedly use to capitalise on the network in which they are enmeshed;[55] it does not seek to encapsulate the corresponding network enabling effects of the different forms of dependency effects and 'risk of dissipation of knowledge'.

Table 10. Conceptualising Network Constraints and Enablers on Collaborative Innovation

Network as Constraint	Network as Enabler
Increased Dependency: *Technological dependence*: Focal actors depend on bundles of different forms of technology available within and through network connections: product, process and marketing technology *Administrative/Logistic dependence*: Focal actors depend on administrative and logistical requirements and practices of other network actors *Path dependence*: Property of sequences of events, steeped in history and therefore influencing the present and the future. Actions of focal actors depend on past actions	Two Network Co-ordination Strategies: *Dissemination*: Actor imposing its specifications and preferences to direct actor, explicitly requesting these to be disseminated to indirect actors *Intervention*: Actor directly engaging in indirect actor's activities to impose and control specifications and performance requirements
Risk of Dissipation of Knowledge: Risk of loss of valuable knowledge and technology through inter-connected relationships may constrain the extent of sharing and openness in relationships.	Access Strategy: Actor accessing and exploiting indirect actors through direct actors

[54] It was noted earlier that dependency due to collaboration is initially on dyadic relationships but, as the dyad is part of a wider network, dependency is ultimately on the wider network of relationships (the latter being the focus of this thesis).

[55] From here on, unless otherwise specified, this is the intended meaning of the term 'network as enabler'.

4.4. The Conceptual Structure

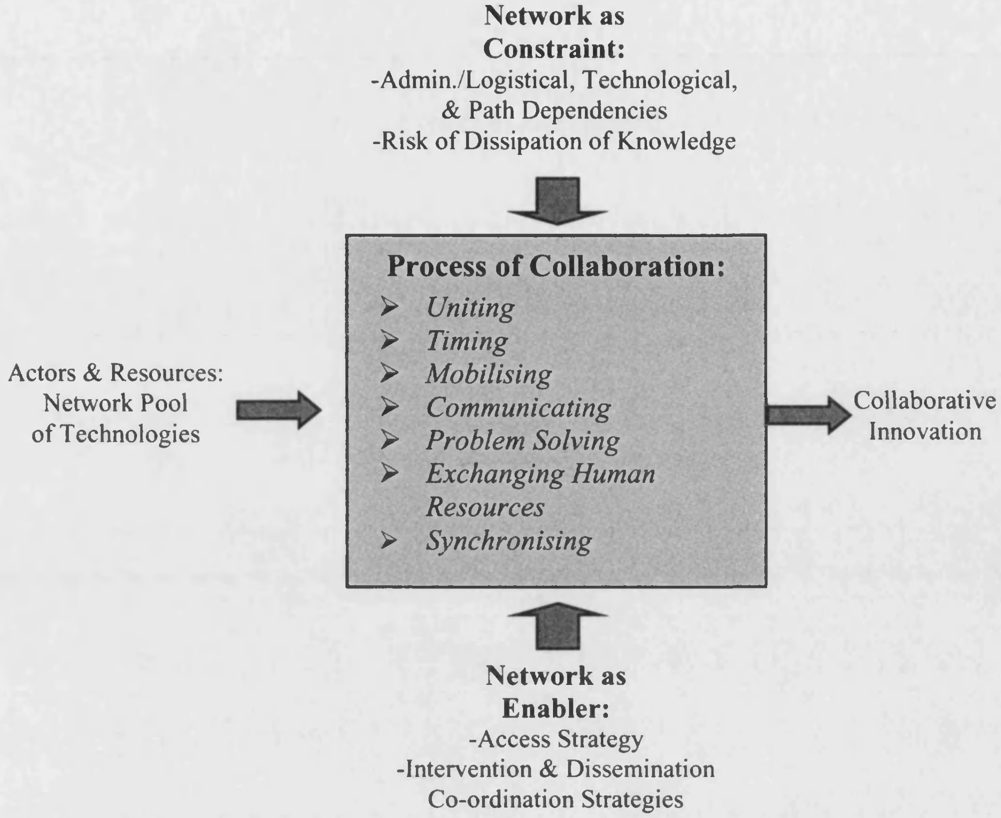
This section presents the conceptual framework that is structured around the set of activities and seeks to capture the complexities of operating in a network of inter-connected relationships, focusing specifically on network enabling and constraining effects on the conduct of each activity.

The basis for the conceptual framework, shown in Figure 17, is two-fold. Firstly it uses a simple functional model known from systems theory as 'IDEF0', which identifies input-process-output factors and mechanisms and constraints of this process (Godwin *et al*, 1989). In operations management the model is often used to describe basic transformation processes. In IDEF0 'Process' refers to the conversion of inputs (resources) into outputs (goods and services). 'Constraints' describe barriers to the process, such as attitudes or general circumstances, which govern the transformation, while 'mechanisms' or 'enablers', may represent people or devices. The IDEF0 model can also depict product development as a transformation process; in Chapter Two this type of model was classified as a conversion model. Despite the simplicity of the IDEF0 model it provides a useful basis for the conceptual framework as it can be used as a simple way to capture how the process of managing innovation projects in networks, is governed by constraining and enabling factors.

Secondly, the conceptual framework incorporates the network model developed by the IMP group (Håkansson, 1987), which identifies the three essential building blocks of networks as actors, resources and activities (ARA). Actors and resources, and the pool of technologies available through these two network components, provide the input in the framework. The set of collaboration activities, which was presented and discussed in the previous section, forms the centre of the framework: the activities 'transform' actors and resources into the output i.e. collaborative innovation. The framework then focuses specifically on the positive and negative effects of the network on the conduct of the activities.[56]

[56] A similar logic was used in Project ION to construct a model of 'networking processes' in supply networks (see Harland *et al*, 2003), although this did not include consideration of the role of the network as constraint or enabler.

Figure 17. The Conceptual Framework



Using the models of 'IDEF0' and 'ARA' it becomes possible to conceptualise the process of managing collaborative innovation projects in networks as a transformation process of actors and resources into innovation through the use of the set of key collaboration activities. The focus and advantage of the framework is that although many factors may constrain and/or enable the collaboration activities, the conceptual framework concentrates distinctly on the role of the network as a constraint and/or enabler of the process of managing collaborative innovation.[57]

Different actors can apply each collaboration activity at any one time. For example, many network actors will be trying to unite with preferred counterparts at any one time. Based on the literature review the activities are assumed here to be useful and beneficial for companies seeking to manage innovation projects. The framework neither testifies to any intention to, nor provides a structure for, testing the usefulness of the activities. Furthermore, it should be emphasised that whilst the activities are firm-specific, they are relationship and interaction focused: the effects of 'network as constraint' and

[57] The focus within 'network as enabler' is, as previously explained on how companies *use* the network to enable innovation: this view of 'enablers' is consistent with the IDEF0 model.

'network as enabler' present different ways of managing (and/or coping with) the activities in the network context.[58]

Based on the derived set of collaboration activities, Table 11 differentiates a number of aspects to be examined within each activity.[59] Moreover, it exemplifies some of the ways in which enabling and constraining network effects may be expected to be manifested in each activity.

[58] It is recognised that although the advantage of the IDEF0-based framework is its simplicity, this may also be its limitation. For example, it does not allow for any sequential analysis of the innovation process. We return to these limitations in the closing part of the thesis.

[59] The term 'managing collaboration activities in networks' does not imply that any one actor alone manages these; in the terms of Ford *et al* (2003) these involve working with, through, in spite of and against other actors.

Table 11. Aspects of Collaboration Activities and Possible Network Effects

Activity	Activity Aspects	Possible Manifestation of Network Effects: Enabling	Possible Manifestation of Network Effects: Constraining
Uniting	• Identification and selection process/being identified and selected • Assessment criteria	• Attractive third party affecting choice • Co-ordination of wider pool of actors	• Ending up with existing suppliers • Avoiding particular suppliers due to confidentiality concerns or relationships with competitor
Mobilising	• Motivational arrangements: • Arrangements for sharing of development cost • Establishment of ground rules and objectives	• Third party helps to motivate/ mobilise • Attempts to influence indirect supplier mobilisation	• Motivational difficulties with existing suppliers • Lack of supplier commitment due to high dependency on other customer
Synchronising	• Synchronising of development procedures • Alignment of technology roadmaps	• Synchronisation with indirect suppliers	• Avoidance of synchronisation with suppliers due to commitment to other company
Communicating	• Communication of design concepts and specifications • Communication of policies and procedures • Communication of performance information	• Increased communication due to attractive third party • Communicating messages to wide pool of actors and encouraging inter-actor communication	• Withholding information from particular actors due to confidentiality concerns • Withholding information due to supplier relationship with competitor
Problem Solving	• Procedure for resolving design or manufacturing problems	• Involving third parties in identifying cause of problem • Assembling large group of actors to resolve problem	• Past actions causing problems • Problems occurring due to commitments to other companies
Exchanging Human Resources	• Allocation of resident design engineers to project	• Allocating resident engineer due to attractive third party • Allocating staff from indirect suppliers	• Avoiding resident engineers from suppliers due to confidentiality concerns • Avoiding resident engineers due to similar arrangement with other company
Timing	• Moment/stage of supplier involvement	• Involving suppliers early due to third parties • Attempts to influence timing of indirect suppliers	• Delaying involvement of supplier due to confidentiality concerns or past behaviour • Delaying involvement due to supplier's relationship with competitor

The indicators of the concepts provided in Table 11 have provided guidance for the empirical data collection and analysis. The possible manifestation of network effects exemplify some of the ways in which enabling and constraining network effects might be expected to be manifested in each activity.

4.5. Conclusions

The literature reveals a variety of activities which companies may benefit from applying when managing supplier-customer collaborations. As all of the existing activity frameworks are more or less partial the most significant ones have been combined and developed into a more comprehensive set of collaboration activities. These are: uniting, mobilising, synchronising, communicating, problem solving, exchanging human resources, and timing.

A conceptual framework has been presented, which has at its centre the set of key activities of managing collaborative innovation that was identified in the literature review. These activities are conceptualised as ways of transforming the product, process, and marketing technologies possessed by actors in the network, into innovation. The framework focuses on the positive and negative effects of the network on the conduct of these activities. Thereby it provides the basis for a more detailed understanding of how each collaboration activity may be enabled or constrained by the network.

The focus on network constraints lies within two main forms. The first is conceptualised as 'dependency effects': when companies choose to source technologies from other companies rather than developing them in-house, they become dependent upon these. Five main forms of dependence have been identified and discussed in Chapter Three: technical/technological, administrative/logistic, path, knowledge, and social dependencies. This thesis focuses on the first three of those. The second network constraint is conceptualised as 'risk of dissipation of knowledge': knowledge may dissipate through network inter-connections. As companies increasingly compete on unique knowledge and competencies such dissipation may present a serious risk.

The focus on network enablers also lies within two main forms. The first has been conceptualised in this thesis as an 'access strategy'; this captures the use of one relationship to gain access to other indirect relationships. This effect is perceived here to be predominantly an informal use of networks, implying a conceding style. The second has been conceptualised as 'network co-ordination strategies'. Two such strategies have been conceptualised: network intervention and network dissemination; they have been formulated as means to capture attempts to co-ordinate or convene actors, resources and activities in the wider network. They are seen as potentially more explicit, assertive and coercive attempts by companies that aim to capitalise on a wider part of the network in which they operate. Thus, the network co-ordination strategies can be regarded as ways to act in a purposive or intentional fashion (Valla, 1998) and as ways to operate at a 'higher' network level.[60]

4.6. Emerging Research Questions

The final part of Chapter Four outlines the research questions that have emerged from the analysis of the current literature on the management of innovation in industrial networks. Following the logic of the conceptual framework these are as follows:

1. For which collaboration activities is the access strategy important in product innovation projects?
2. In which collaboration activities are network co-ordination strategies applied in product innovation projects?
3. How does the risk of dissipation of knowledge to other network actors affect different collaboration activities in product innovation projects?
4. How do different types of network dependency affect different collaboration activities in product innovation projects?
5. In which situations might network co-ordination strategies be appropriate?
6. In which situations is the conduct of collaboration activities most likely to be constrained?

The set of research questions outlined here forms the basis of the empirical data collection. Questions 1 to 4 are explanatory in focus whereas questions 5 and 6 are more managerially orientated. Chapter Five identifies and discusses the most appropriate research strategy for exploring these questions.

[60] 'Higher' is used here the way four levels of network analysis were described in Table 4.

Part Two:
Research Process and Empirical Findings

Overview of Part Two

The chapters in Part Two of this thesis revolve around the empirical phase of the study.

Chapter Five describes and justifies the research strategy and methods, in the context of the critical realist research philosophical perspective adopted in the thesis. The empirical data collection comprised two empirical investigations: an exploratory mini-survey and four in-depth case studies. The first, exploratory, phase involved five focal network companies in pharmaceutical/biotechnology and automotive industries; the second, analytical, phase involved four focal companies in the automotive and telecommunications industries and a selection of suppliers and customers.

Chapter Six reports the findings from the exploratory mini-survey and draws out the key lessons from this phase and conceptual and empirical implications. Chapter Seven presents, in sequence, the findings from each of the four in-depth case studies, including the context and network effects on each collaboration activity identified within each case. Chapter Eight focuses on cross case comparative analysis of the problem areas of the four case studies and hence draws conclusions on the research questions. The findings are discussed in relation to prior research, thereby addressing the contribution and implications of the findings. Part Two completes with a discussion of lessons on the conceptual structure and observations on the limitations and validity of the research findings.

CHAPTER FIVE: RESEARCH PHILOSOPHY AND METHODOLOGY

5.0. Introduction[61]

Chapter Five provides an overview of the research philosophy and methodology adopted in the thesis, and explains the decisions about research strategy and data collection methods. It begins by discussing the philosophical and epistemological perspective adopted, making a case for the chosen critical realist philosophy by distinguishing it from the philosophies of positivism and phenomenology. A discussion of the research strategy follows, explaining why the so-called 'abductive' approach, advocated by, for example, Dubois and Gadde (2002), provides the most accurate reflection of the actual process. The philosophical stance and the approach determine what form of research strategy is appropriate; the subsequent section outlines the research strategy: four in-depth case studies preceded by an exploratory mini-survey. Issues concerning units of analysis, case selection, and analytical methods employed are discussed, and an evaluation of issues of research credibility concludes the chapter.

5.1. Research Philosophy and Epistemology

Inter-organisational relationships have been researched and analysed using many different methodologies. The IMP Group has traditionally resorted to in-depth case studies based on face-to-face interviews or larger scale questionnaires. The reasons for this have been many, but a significant factor has been the practical problems of carrying out this type of research in terms of attempts to understand the complexities of the phenomena in question. As Easton convincingly argues (e.g. 1998; 2002), there is, however, also an epistemological defence for adopting case research as the methodology to the study of networks. Easton promotes a 'realist' epistemology as the most appropriate way to study relationships and networks. However, before outlining what this means, it is appropriate to consider the basic aim of conducting research in the first place.

[61] In this chapter the first person, 'I' is used to facilitate easier explanation of methodological decisions.

According to Easton (1998), research is fundamentally concerned with seeking valid explanatory knowledge. The concept of 'explanation' is intrinsically linked to the problem of causality. Explanation, however, means different things, and is identified in different ways, in different research philosophies.

In positivism, which continues to dominate social sciences in various forms (not least in the USA), 'explanation' - or causality - is uncovered through the identification or analysis of event regularities within systems (Ramsay, 1998). Ontologically, human actors are assumed to be passive agents observing and recording events.

The view of explanation in phenomenology (or constructivism or interpretivism) is very different. Reality is regarded as socially constructed rather than as an objective phenomenon: there is not one reality but many, depending on the observer. Ontologically, humans are assumed to be active, self-aware, and capable of perceiving and generating meaning (Ramsay, 1998). Phenomenological research therefore focuses on human interpretations of meanings perceived in phenomena and events, rather than events themselves. A closer look at positivism is appropriate at this point to appreciate the background and assumptions of this philosophy.

5.1.1. Positivism

Positivism originally emerged in the 'hard' physical sciences from the work of, for example, Comte, Hume and Kant. Comte chose the word 'positivism' on the ground that it indicated the 'reality' and 'constructive tendency' that he claimed for the theoretical aspect of the doctrine. It can be argued that the world of positivism reflects a mechanistic view of the world, which can be associated with Newton, whose release of 'Principia' in 1686 founded a mechanistic view of the world, which coincided with the rise of an early factory civilisation, and emphasised stability, order, uniformity, and equilibrium. It concerned machine-like closed systems operating independently of the outside world and it implied that a linear relationship between cause and effects was assumed in which small inputs yielded small predictable results (Prigogine and Stengers, 1984). Hence, positivism is particularly suited to the study of closed systems.

Positivism is based firmly on the premise that knowledge has to be observed empirically in the form of testing hypotheses that have been derived through a process of deductive reasoning. Hence, the positivist researcher examines existing theory and deducts hypotheses to be tested empirically on a large number of representative cases so that these can be statistically analysed for correlations and patterns in events. These correlations or patterns are then assumed to reflect causes and effects (rather than simply co-variances) and generalisations can be made.

The emphasis on empirical testing or verification has meant that positivism has become known in various forms as logical empiricism. As such it was - and still is - a response to what some people would call 'arm-chair theorising'. Law-like relationships are hypothesised among a set of operationalised, and therefore empirically measurable, constructs and data are collected and analysed to identify correlation (Easton, 1998). The more tests that are applied, the more confirmation or dis-confirmation.

The problem with positivism is that few social systems, including business systems, can be described as 'closed'. In fact, according to Bhaskar (1978) three conditions have to be fulfilled if a system is to be described as fully closed:

1. The extrinsic condition:

A closure thus depends upon either the actual isolation of a system from external influences or the constancy of those influences (Bhaskar, 1978, p. 74).

As an example, it is practically impossible to establish whether the overall success of a company (such as increase in turnover) over a given period of time is the result of a specific internal initiative (for example a business process re-engineering programme) or the result of some external change, such as a decrease in interest rates amongst other factors.

2. The intrinsic condition:

This condition is also very difficult to satisfy in social systems. Bhaskar (1978) calls for the necessity for the 'internal structure' of the object, individuals, or processes making up the system to be constant. This condition is very difficult to satisfy in human systems as people undergo changes and interpret and reflect upon events as they go along. It is a condition that truly distinguishes social systems from machines.

3. The non-additive principle:

Finally, Bhaskar (1978) develops the non-additive principle which stipulates that closure can only be attained if the overall performance or behaviour of the system can be derived as an additive function of the behaviour, or states of the individual system components (Ramsay, 1998). This is clearly related to the intrinsic and extrinsic conditions, but seeks to confirm that no other factors influence the object being studied.

The positivist (or empiricist) conditions for closed systems, as interpreted by Bhaskar (1978) are arguably difficult to fulfil in social systems research. One may think of examples and (brute) data that satisfy the conditions, such as number of employees, sales turnover, or purchasing expenditure. However, inter-organisational relationships and networks do not easily fit these conditions. In fact, networks are defined as 'open systems'. In other words, they have no boundary even if for the purpose of analysis one may draw an arbitrary boundary around a network based on, for example, selected inclusion of those relationships related directly or indirectly to the unit of analysis (Cova *et al*, 1998; Harland *et al*, 2003). Thus, I believe that a positivist orientation is inherently problematic for the study of collaborative innovation in networks.

5.1.1. Phenomenology

The premise of phenomenology is that reality is merely a social construction. Phenomena studied by researchers only exist to the extent that they are studied and interpreted by the researchers, there is no underlying objective or ultimate truth (Mir and Watson, 2001). Human interpretations of meanings perceived in phenomena and events, rather than events themselves, are what matter to the Phenomenologist.

From a phenomenological perspective it is logical that different researchers observe different things and offer different explanations. An example is the case of 'strategic networks' (e.g. Jarillo, 1988) versus 'industrial networks'. Jarillo studied the Italian textile manufacturer Benetton and observed and concluded that Benetton created and managed its network in a strategic manner and generated a competitive advantage through a deliberate strategy. Womack *et al* (1990) arrived at similar conclusions based on studies of the automotive industry, although they used the terms 'supply chain' and 'lean enterprise' instead of 'network'. These findings are in contrast to the findings of the IMP Group, which has conducted a large number of in-depth case studies and surveys, and which continues to find that networks emerge, are not controlled by any single actor within it, and actors embedded within the networks are highly constrained by the actions of other network actors.[62] The phenomenological explanation for this divergence is that researchers, who investigate similar phenomena, tend to see what they are capable of seeing - or would like to see. Shaped by previous research experience and armed with a set of models and assumptions, researchers interpret findings according to their own paradigm (Kuhn, 1962). This is the reason why Ford *et al* (2003) stress the significance of different network pictures: people form their own network pictures based upon their perception of the world around them; some see simple supply chain structures, others see complex networks. One may speculate that if Jarillo, or his colleagues, studied the same cases as studied by the IMP group it is plausible that he would find that network actors behaved in similar ways to Benetton. Hence, cases such as Benetton may be unique but a more likely explanation for this variation in network findings may be found in the different philosophical orientations of the researchers, and thus their beliefs and assumptions. These include ontological differences in assumptions; researchers within the IMP tradition assume that network actors (ultimately humans) *interact* within a complex network of actors. They can act within the network, but the network also ultimately determines the impact of their actions. In contrast, strategic management academics, such as Jarillo, tend to assume that humans have more power to *act* and determine the direction and destiny of other actors.

Different forms of phenomenology (or constructivism) exist, where some are more radical and uncompromising than other more moderate versions (Hess, 1997 cited in Kwan and Tsang, 2001). Nevertheless, the danger with a phenomenological orientation is that *if philosophical positions* determine *research findings, then reality has no input to and control over scientific research* (Kwan and Tsang, 2001, p. 1164). Hence, no research findings can be objectively assessed and theories are but an act of the researcher's generation instead of a formalisation of underlying reality (Mir and

[62] This dichotomy between two schools of thought within network research is naturally exaggerated. However, a marked difference between the two schools arguably exists in their most archetypal versions.

Watson, 2001). The standpoint adopted in this thesis was that the phenomenological philosophy for these exact reasons, did not offer a satisfactory solution.

5.1.2. The Philosophical Stance Adopted in this Thesis: Critical Realism

Easton (1998, 2002) advocates a realist 'apologia' to the study of relationships and networks as a better alternative to e.g. positivism and phenomenology. According to Easton the fundamental assumption of realism is that "there is a reality 'out there' waiting to be discovered and that reality is independent of us" (1998, p. 76). He stresses that we are not talking about a naive reality, which is easy to discover or self-evident, but he disputes the argument that it is socially constructed. Easton suggests that the researcher has to remain critical and objective and thereby try to uncover 'reality' rather than assume it is an entirely social construction in the mind of the researcher.[63] According to Lewis (2001) "critical realism asserts that the world investigated by science consists of objects that are structured and intransitive: *structured* in the sense that they are irreducible to the events of experience; and *intransitive* in the sense that they exist and act independently of their identification" (p. 487). Hence, reality does exist in an independent form away from the researcher but it is not a simple objective reality in the positivist sense.

The discussion of ontological differences between the positivist and phenomenological philosophies highlights the importance of maintaining objectivity and reliability. The discussion also indicated the importance of understanding in the context of complex contingencies. Although descriptive studies may be very interesting it is difficult to learn from studies, which do not seek to explain *why*, for example, decisions are taken or *why* a company is successful. In a critique of the influential work on lean production by Womack *et al* (1990), Cox (1996) asserts that the authors showed very limited *understanding* of the particular circumstances that allowed Japanese auto assemblers to exert such great control over their supply chains.[64]

[63] The recent debate between Mir and Watson (2001) and Kwan and Tsang (2001) shows that there is much uncertainty as to the differences between constructivist (or phenomenological) and critical realist philosophies, and that there are different interpretations of their respective merits.
[64] Indeed Cox contends that the fact that companies across the world have attempted to replicate the Toyota production line and supply chain without proper understanding of the circumstances which allow Toyota to behave the way they do, is highly problematic.

The need for understanding brings us back to the question of *explanation* and therefore also the unavoidable problem of causality. The present research has sought to identify causality, as it is argued that without an understanding of causality we do not know why companies act in a given way and whether other companies can learn from their ways of acting. Causality in critical realist terms, however, does not concern relationships between discrete events (cause and effect), but as Easton explains (1998), referring to Sayer (1984), "the 'causal powers' or 'liabilities' of objects or relations, or more generally their ways-of-acting or mechanisms" (p. 105). The important difference between causality understood as cause-and-effect, identified through correlation, and as causal power is that causality is contingent. Extrinsic and intrinsic contingencies are used to provide explanations via causal mechanisms (Tsang and Kwan, 1999). Thus, rather than identifying that there is a relationship between, for example, the nature of technology and a company's approach to innovation, this inquiry seeks to identify those contingent factors which explain why certain practises seem to work and the mix of mechanisms which allow this to happen.

However, this thesis does not intend to deliver true explanations of reality on its own. The critical realist orientation implies that verification and falsification are never conclusive, especially in social sciences, thus replicability of empirical tests is key to establishing 'reality' (Mir and Watson, 2001, Bhaskar, 1978). Such replicability or critical testing of theories need to be carried out continuously (Kwan and Tsang, 2001). Therefore, this thesis forms part of an overall research agenda into the problems of managing collaborative innovation in networks. I am hopeful that it will be regarded as a piece of research that offers another critical perspective on and evaluation of existing theories. I highlight a variety of complex contingencies, or contextual factors, which appear to influence the patterns in the findings. However, further evaluation will be required by other researchers to continue the research in the search for underlying (but by no means ultimate) truth. The main features of the philosophical stance adopted in this thesis are summarises in Table 12.

Table 12. Beliefs and Assumptions of this Thesis

Dimension	Perspective
Nature of reality	Neither objective nor socially constructed; reality consists of objects that are structured and intransitive: structured in the sense that they are irreducible to the events of experience; and intransitive in the sense that they exist and act independently of their identification" (Lewis, 2001, p. 487).
Explanation and causality	Explanation is sought through "'causal powers' or 'liabilities' of objects or relations, or more generally their ways-of-acting or mechanisms" (Sayer 1984, p. 105). Extrinsic and intrinsic contingencies are used to provide explanations via causal mechanisms.
Evidence	Never conclusive. Continuous replicability of empirical tests is key to establishing 'reality' (Mir and Watson, 2001, Bhaskar, 1978).
Possibility of generalisation	Analytic not empirical generalisation is possible (Yin, 1989)

5.2. Research Approach and Process

The research approach can be seen as one step from the choice of philosophical orientation towards the more practical methodological choices. The mainstream literature tends to distinguish between two approaches: deductive and inductive. A deductive approach logically follows from a positivist philosophy, testing a hypothesis derived through deductive reasoning, whilst an inductive approach follows from a phenomenological philosophy i.e. formulating theory from empirical data. A deductive approach is usually based upon quantitative data, whilst an inductive approach is more geared towards a qualitative approach. In general, an inductive approach is more flexible, providing opportunities to address any unexpected issues that may arise during the research. As identified by Preece (1994), the conclusion of a piece of inductive research can contain new ideas, which may be enhanced by additional supporting evidence arising from the research undertaken.

The inductive approach has been regarded – often implicitly rather than explicitly - by many qualitatively minded European relationship and network researchers (such as the majority of IMP scholars) as the natural way to approach research projects. Others lean more towards a deductive approach, systematically deducting hypotheses from the literature. In reality research projects that examine inter-company relationships and networks are often neither entirely inductive nor deductive. The present research project has been approached from a mixture of the two extremes; at times relying on literature, other times relying on own experience and empirical data collection. Dubois and Gadde describe the process as 'systematic combining' (2002). The process can be described as an iterative learning process rather than a systematic process of either deduction or induction. Dubois and Gadde have made similar observations on IMP-based research. They argue that the process is one of abduction, defined by Ayer as a process that "consists in studying facts and devising a theory to explain them" (1968, p. 85). Ayer's definition implies that abductive research does not work from a preconceived conceptual framework derived from the literature, but rather "is successively modified, partly as a result from unanticipated findings, but also from theoretical insights that are gained during the process. This approach creates a fruitful cross-fertilisation where new combinations are developed from established theoretical concepts and newly developed ones when confronted with reality" (Dubois and Gadde, 1999, p. 4). Systematic combining thus implies continuous improvement of the conceptual structure as well as the crucial role of theory in interpretation of empirical observations. It becomes a matter of going 'back and forth' (Dubois and Gadde, 2002 p. 555). To some extent the empirical fieldwork parallels theoretical conceptualisations. An advantage of an abductive approach is that as researchers we do not have to claim to have been free from the influence of prior knowledge, as implied by methodologies such as grounded theory (Glaser and Strauss, 1967). Furthermore, it presents a more accurate and authentic picture of the cumulative process and sometimes almost chaotic development of my understanding of concepts and empirical findings.

Figure 18 provides an overview of the research approach and process with specific reference to the relationship between the different stages of refinement of the conceptual framework and the theoretical and empirical investigations.

Figure 18. Development of Conceptual Framework

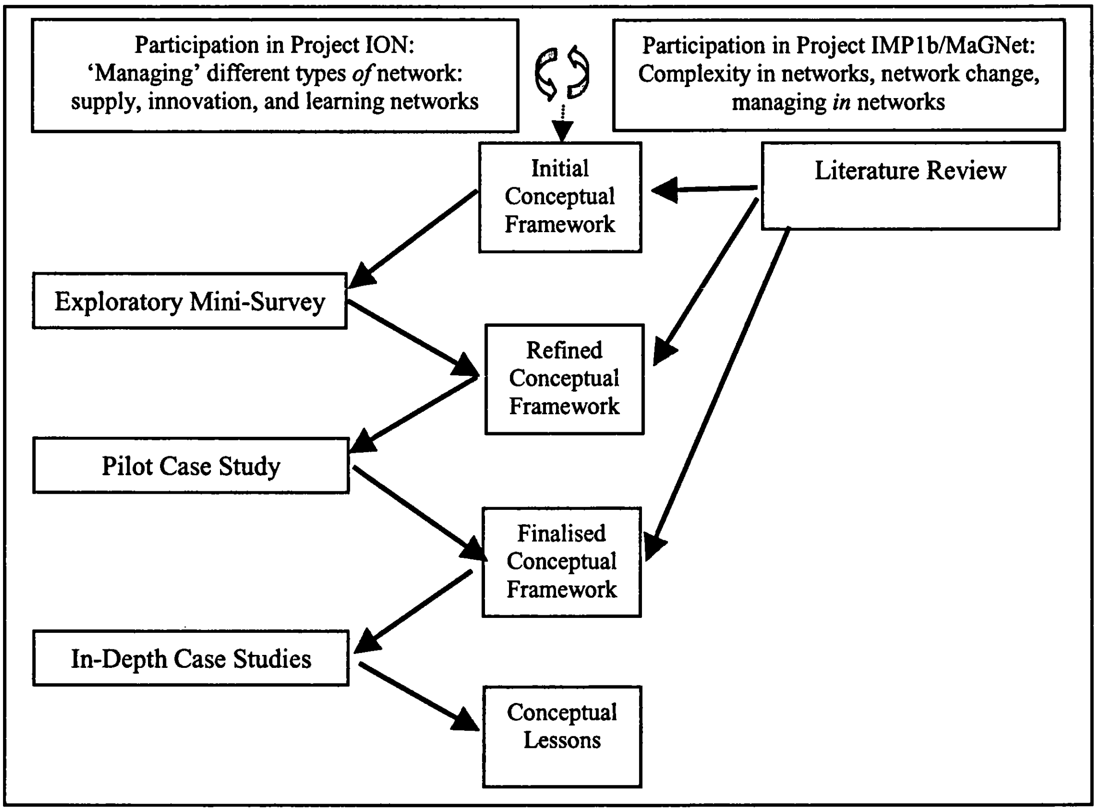


Figure 18 shows that Project ION served as an initial point of inspiration, both empirically and conceptually. Founded largely on an operations and supply chain-orientation, Project ION delivered a conceptual model for the creation and operation *of* different types of network (Harland *et al*, 2003), in addition to a taxonomy of supply networks (Harland *et al*, 2000). The mainly industrial marketing based IMP and MaGNet projects (e.g. Naudé *et al*, 2002) revealed a more comprehensive understanding of the complexities and implications of managing *in* networks, and to some extent served as a counterweight against the more mechanistic supply chain conceptions gained during participation in Project ION. Therefore, the inter-play between the two research projects inspired the theoretical approach and conceptual structure of the thesis. In this way the idea and concept generation in the research project mirrored the interaction view of the innovation process reviewed in the innovation and network literature.

An initial conceptual framework was devised following a preliminary literature investigation, using Projects ION and IMP1b/MaGNet as specific sources of inspiration. The conceptual framework underwent several iterations based on both conceptual insights and empirical findings. The initial framework was applied in the first stage of the empirical research: an exploratory mini-survey. Lessons from this exercise were used to generate a revised version of the framework combined with further investigation of the literature undertaken during the exploratory survey. This involved refinement of the set of collaboration activities and operationalisation of network effects. The first case study functioned as a pilot case, after which a change was made to the collaboration activities. However, this was as much due to a conceptual realisation following further examination of the literature. Similarly, the specific nature of the research questions formulated after the exploratory mini-survey gradually evolved during the course of the case study data collection and analysis.

The risk of continuous refinement of the conceptual framework was that it would make cross-case comparisons problematic, as potentially each could be based on a slightly different version.[65] Hence, the framework was kept constant during the exploratory mini-survey, during the pilot case and during cases two to four.

5.3. Research Strategy

Chapter Four culminated with an outline of six research questions that concern the management of a set of collaboration activities and problems and opportunities of controlling these activities in networks. The research strategy needs to be able to capture the inherent dynamics and complexities of such complex inter-organisational systems, in which the boundaries of phenomena under scrutiny are fuzzy. It also needs to allow access to the different actors involved in the collaboration projects chosen for study.

This section outlines the research strategy of the part of the thesis that concerns the empirical data collection. Following the advice provided by Easton (1998, 2002) I decided to adopt a case study strategy, however, I decided that an exploratory mini-survey was appropriate to try out emerging ideas and concepts. The following section therefore explains the purpose and nature of the first stage of empirical data collection: an exploratory mini-survey. This is followed by a more extensive explanation and justification of the case study research strategy.

[65] Such a risk would be less significant in single case research as advocated by e.g. Easton (1998), however, in Section 5.3.2 it is argued why it was decided to conduct more than one case.

5.3.1. Initial Data Collection: An Exploratory Mini-Survey

The purpose of the exploratory mini-survey was:

1) to explore whether and how focal companies, engaged in collaboration with external parties for the development of new products and technologies, apply the set of collaboration activities emerging from the research
2) to explore how the management of the activities may be constrained and/or enabled by the surrounding network
3) to explore possible differences in the management of collaboration activities and network effects across different circumstances

Given the exploratory nature of the study it was decided to focus on two industries: automotive and biotechnology/pharmaceutical. These industries were chosen because of their relative importance to British industry and because existing research from which the collaboration activities had been identified often include these two industries, but have not fully considered the problems and opportunities offered by the surrounding network. 'Best practice' of managing collaborative ventures could therefore be expected in these two industries. An attempt, however, was made to include both large influential firms, which might be expected to behave 'intentionally' and possibly seek to exert control over the network, and relatively smaller firms whose behaviour in contrast might be expected to be one of 'coping'.

Each interview focused on a specific product or technology development project and the role of each collaboration activity during or related to that particular project. Current or recent projects of particular importance to the companies were chosen to reduce the risk of biased responses, such as post-project rationalisation. Although all activities were effectively conducted within dyadic relationships by the focal firms the network perspective implied that the particular focus was on the inter-connectedness of each activity. The significance of this 'inter-connectedness' was captured through the notion of 'third party relationships'. The activity of 'co-ordinating' specifically sought to capture the extent to which efforts were made to co-ordinate activities beyond one-to-one dyadic relationships, bringing a wider group of actors together for the development project and utilise all their individual technologies and capabilities.

The interviews were semi-structured with a list of specific questions around which a discussion took place. Mapping, or drawing, of the network was used as a technique to assist and focus discussions.[66] Each interview lasted app. two hours and was structured around the following headlines:

1) Company background
2) Identifying appropriate technology
3) Mapping/drawing network pool of technologies and identifying collaboration partners (upstream, downstream, and others)
4) Management of collaboration activities within the network (as drawn)

The interviews were all carried out as confidential. This was necessary given the sensitivity of the subject, especially as some of the projects in focus were still in development. All but one interviews were taped and transcribed or summarised, and returned to respondents for comments and corrections. Efforts were made to establish the possibility of referring to company names, which was successful only in the case of the car engine development project, analysed through TVR Engineering as the focal point. The five new product development projects being studied, the units of analysis, the focal companies involved in the study, and the position of the respondents in focus were as shown in Table 13 below:

Table 13. Exploratory Survey Characteristics

Project: Unit of Analysis	Focal Company	Respondent	Industry
Development of Car Engine	Small Car Manufacturer: 500-600 employees	Chief Design Engineer	Automotive
Development of Exhaust System	Large Auto Supplier: 4000-6000 employees	Supply Development Manager	Automotive
Development of Car	Large Car Assembler: 35000-40000 employees	Logistics Manager	Automotive
Development of Viral-drug	Small Biotech Company: App. 120-160 employees	Business Development Manager	Pharmaceutical
Development of Compound Drug	Large Pharmaceutical Company: + 50.000 empolyees	Purchasing Director	Pharmaceutical

Two consequences of the nature of the respondents are worth-wile emphasising. Firstly, the wide spread of people being interviewed helped to obtain a useful understanding of the type of business functions that are likely to be concerned with the problem of relationships being embedded within a complex network. Secondly, the negative

[66] The mapping identified actors as nodes (most often companies but also individuals) and their

consequence of the wide spread of the background and perspectives of respondents, is an unavoidable loss of consistency. However, to minimise this, efforts were made to ensure that all interviewees had been closely involved in the chosen new product development project.

The data from the exploratory interviews were analysed and interpreted through a process of transcription, respondent validation, and matrix construction. The analysis process followed the same procedures as used in the in-depth cases, albeit the process was less extensive (see Section 5.6).

5.3.2. Data Collection: Four In-depth Case Studies

I have offered a number of arguments why not only a critical realist philosophy, but also case research in particular is suited to the study of networks. Therefore, case studies were chosen as the core part of the research strategy.

A case study has been defined by Yin (1989) as "an empirical inquiry that: investigates a contemporary phenomenon within its real life context; when the boundaries between the phenomenon and context are not clearly evident; and in which multiple sources of evidence are used" (p. 23). This type of inquiry suits the study of collaborative innovation in networks, as previously discussed, due to the fuzzy boundary between companies, relationships, and networks. Two other arguments are the large number of human actors within the loosely defined structures that make up networks, and the focus of the study on innovation, which is a dynamic concept, more easily captured in a case study (Eisenhardt, 1989).[67]

Unit of analysis

The research study is concerned with collaborative innovation; hence the process of collaborative innovation formed the central unit of analysis. By implication, there are three relevant issues to consider in relation to unit of analysis: relationships, networks, and innovation projects. These are considered in the following.

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technologies and components.

[67] Eisenhardt's proposed theory building case study process is positivistic and thus relies more on a hypothesis shaping approach than what is proposed here. See Dyer and Wilkins for a critique of her suggested approach (1991), which they argue is too concerned with the development of constructs and measurement instruments (a critique I largely support).

Relationship focus

Networks include relationships of different degrees of formalisation and closeness/level of involvement. As the research project concerns collaborative innovation in networks, it was deemed essential that the innovation project within each case include both customer and supplier relationships in addition to other, more horizontal, forms of relationship. Some of these had to be high-involvement or collaborative.

It was deemed to be inappropriate to 'measure' the degree of collaboration in any quantitative manner. However, an indication of the extent to which the key relationships that had been examined could be described as collaborative was nevertheless seen as important. Therefore, the conceptual framework was used as the basis for devising appropriate indicators of collaboration.[68] This model is shown below:

Figure 19. Extent of Collaboration in Key Focal Firm Relationships

Indicator:	**Non-Collaborative** ⟷	**Collaborative**
Uniting	- Dictation - Formal vendor assessment procedure	- Joint choice - History & trust important
Timing	Involved in detail engineering or later	Involved in idea generation or concept development
Mobilising	- No sharing of development costs - Individual goals	- Sharing of development costs - Shared goals
Communicating	- Non-transparent exchange of information - One-way flow	- Transparent exchange of information - Two-way flow
Exchanging HR	No allocation of engineers to project	Engineers allocated to project
Synchronising	- Imposed project plan - Isolated technology development	- Agreed project plan - Alignment of technology development
Problem Solving	Blame of other party	Focus on root cause analysis

The model was used to map the profile of each of the relationships that had been investigated. This exercise indicated my interpretation of the level of collaboration displayed within the conduct of each activity, subsequently validated by central focal firm respondents. Whereas the exercise could only result in and serve as a crude indication, it highlighted the perceived levels and variations of collaboration within a selection of the focal firm's key relationships as well as the overall collaboration profile of some of the focal firm key relationships.[69]

[68] The collaboration activities were regarded as useful indicators of collaboration, as these represented different ways in which actors could develop and/or increase their collaboration with other actors.

[69] The exercise only concerned relationships with those companies that had been chosen for interview by the researcher in consultation with the focal companies.

Network focus: focal firm network perspective
The focus in each case was on sets of inter-organisational relationships, consistent with the IMP tradition. However, unlike much IMP research the focus in my cases was on focal firm networks, or the network as seen from the perspective of a single (focal) actor.

The literature review revealed that the majority of case studies to date in the area of innovation and networks have centred on OEMs or assemblers. The cases conducted as part of this thesis are different as the majority have as their focal points a key 'first tier' supplier, although in one case the focal firm is more appropriately classified as an OEM. Each case focused on how the focal firm managed the collaboration activities within the network of supplier and customer relationships in which it was embedded and thus conditioned by other network actors.

The focal firm network perspective is different from a non-focal firm network perspective, as it includes only those relationships that are, directly or indirectly, connected to the focal firm. My use of the term 'focal firm' simply reflects the chosen point of entry to the network: a focus point. The focal firms in the cases are not claimed to be 'focal' in the sense that they are natural network centres or hubs the way some authors interpret and apply the term 'focal' (e.g. Jarillo, 1988). Such a view of networks is problematic, as it assumes that whole networks exist, and are defined, by their relationships with a single network actor. From an IMP perspective there are no natural network centres, even if some actors may be significantly more powerful than other actors (Harrison, 2001).

A major limitation of a focal firm network perspective is the fact that it is restricted and arguably biased and distorted. From an IMP perspective it gives an incomplete view of the world surrounding the focal firm and the actual or potential influences on it (Ford *et al*, 2003). The rationale for the focal firm focus adopted in this study was methodological and indeed pragmatic. 'True' non-focal firm network research is highly complex and time consuming, but it also presents a problem of defining the network boundary (Cova *et al*, 1998). In this research several interviews were conducted within each focal firm and one interview (with one or two respondents) was conducted with each external actor. This was done to compensate for the disadvantages of a pure focal firm network perspective. In practice, the problem with non-focal firm network research is that if one were to conduct empirical non-focal firm network research several interviews with several actors would be required. Multiple cases become practically impossible and the problem persists that there are always more relationships to pursue.

Project focus: product or technology innovation?
A considerable decision concerned whether to focus on product or technology innovation or development projects. Initially, it was the ambition to concentrate on technology development, as the literature had indicated that some of the wider implications of networks would be of particular relevance to technologies rather than products (e.g. Lundgren, 1995; Håkansson, 1987). However, the ambition to focus on technologies proved to be problematic.

The decision to adopt a focal firm perspective influenced whether a technology would be an appropriate unit of analysis. To capture technology development from a focal firm perspective, it was decided that the technology to form the centre of each case would need to be 'micro' and product application orientated rather than macro and 'blue sky' orientated.[70]

It proved problematic to identify suitable technology development projects, which involved high-involvement customer and supplier relationships. Pilot case facilitation work, involving three interviews in one potential but later abandoned case, indicated that companies may engage in a number of both product and technology development projects. These early facilitation efforts included a major telecommunications OEM, an engineering supplier, and a boat manufacturer. However, technology projects were predominantly internally concentrated and very R&D controlled (and indeed more Research than Development focused). The use of external actors in any collaborative manner seemed to be limited.

Having spent approximately one year unsuccessfully trying to identify appropriate technology development projects, I decided to focus on product development projects. Underlying technologies applied in the products that were studied were examined as a context issue rather than units of analysis in their own right. Thus, it was decided to focus on a set of product or product component innovation projects, which have applied new process and/or product technology.

Case Selection

At the heart of case study methodology is the idea that the case study is studied in its own right, not as a sample from a population (Robson, 1997). The present research project has involved four in-depth cases or what has been described as multiple cases (Yin, 1989). The multiple case study strategy has not been adopted in an attempt to achieve statistical generalisation to satisfy a positivist requirement. Case selection is not the same as sampling in quantitative research (Sykes, 1991). Rather, a multiple case study strategy was adopted to externally validate the findings from a single case, to ensure that any one case is not unique in any way (Eisenhardt, 1989). Multiple cases also enable an improved understanding of each case, that is, what the contingent factors are in each that differentiates the cases from each other. Contingent factors are important in critical realist studies and hence in this study; my study seeks to identify different situations in which collaboration activities are constrained or enabled by the network in which they are embedded. To put it more succinctly, the aim of producing case studies and indeed multiple cases is *analytical generalisation* (Yin, 1989); generalisation not to a population but to the theoretical propositions and conceptual framework (see later section on External Validation).

Although it makes little sense to talk about sampling when choosing case studies it is still important that there is a logical rationale for case choice. According to Robson (1997) cases have to be selected either so that the theory would suggest that the same result would be obtained or that predictably different results will be obtained (see also Eisenhardt, 1989). The cases shared a number of important characteristics, such as sector (automotive and telecommunications) and except from one case supply chain position ('first tier'), and size (medium to large), and UK-based focal firms (although all with complex global links). They were deliberately chosen from two industries to ensure some familiarisation and learning of specific drivers and issues within one industry without the risk of appearing as a sector-specific study. The two industries were chosen on the basis of my personal interest and level of understanding e.g. from previous research projects. In addition, the fact that both industries constitute two major

[70] Lundgren's study is an excellent example of a more 'macro' based, non-focal firm focused

UK industries that are commonly regarded as 'flagships' of not only UK but also global manufacturing, was also taken into account: the automotive industry as 'the industry of industries (Drucker, 1946), and telecommunications arguably as the new industry of industries.

Table 14 provides an overview of the nature of the four case studies.

Table 14. Case Study Characteristics

	Fuel Tank Development Project (Pilot Case)	Asian Car Development Project (Case No 2)	Base Station Equipment Development Project (Case No 3)	Interception Gateway Development Project (Case No 4)
Project	Focus on fuel tank development as part of vehicle development.	Vehicle development and plant/supply development in Asia.	Development of high frequency component for base stations.	Development of interception technology for data transfer on telecoms networks.
Focal Company:	JV between UK company and European company. JV small but both JV partners large automotive 1st tier suppliers.	1st tier engineering supplier to vehicle manufacturers: Turnkey responsibility.	Large multinational 1st tier electronics supplier to telecoms network providers.	Telecoms networks OEM: major global player.

The pilot case concerned the development of a fuel tank module for a Japanese vehicle manufacturer's new car development project. The fuel tank applied a recently developed material technology. The focal company, 'EuroPart', which operated as a 'first-tier' supplier to the automotive industry, is a joint venture between a UK company and a continental European company. The data collection comprised twelve semi-structured interviews: seven internal and five external interviews. It was attempted to collect performance data through a performance questionnaire to establish process and output performance of the innovation project. However, as discussed later this proved to be problematic and it was subsequently decided to incorporate part of the questionnaire into the interviews.[71]

The second case concerned the development of a car; the focal company in the case, AutoEngineer, had the full turnkey responsibility for vehicle design and engineering, and plant construction in Asia. The car project applied a new material technology and

technological innovation study.

[71] As Eisenhardt (1989) explains one of the advantages of case studies is that they allow for adjustment of, for example, constructs and research instruments as the researcher learns from individual cases.

was further complicated by involving the simultaneous development of a plant and supplier network in Asia. The case study was based on seven semi-structured interviews within AutoEngineer and three external interviews with two key suppliers and the customer, a vehicle manufacturer.

The third case study revolved around the development of a new component for base stations manufacturers, referred to as the 'RFC' project. The project was a new application of proven technology. 'TelePart'; the focal company in the case, was a telecommunications 'first tier' supplier. The TelePart case was based on twelve interviews: eight internal and four external interviews.

The fourth and final case study was distinct from the other cases as the project concerned the development of interception technology for data transfer on telecommunications networks, a technological shift from second generation to third generation technology. The focal company in the case was 'NetCom': a telecommunications OEM. Hence, it was a differently positioned focal company compared with the focal companies in the other three cases. In addition, this case differed from the other cases in that the project concerned, from NetCom's point of view, a component technology, rather than a product. The case was based on five interviews in total: four focal firm interviews, of which one was conducted by telephone as it was with a USA-based respondent, and one interview with the key supplier of the interception technology.[72]

5.4. Data Collection

In addition to three interviews conducted during pilot facilitation the four cases involved in total 39 semi-structured interviews with managers at different levels and from a variety of functions within the focal firms and with a selection a key suppliers and customers. Moreover, four follow-up meetings were held with the main contact within each case to validate findings (see later). They were taken as opportunities to make further enquires about recent developments and areas of ambiguity and to validate

[72] In the Interception Gateway case only one supplier in addition to the focal company could be interviewed. The supplier was the provider of the technology. No customer could be interviewed, as the effective customer was a government law enforcement agency. The high degree of confidentiality restricted further external interviews.

observations, perceptions and conclusions. These meetings included both face-to-face and telephone meetings. In total including the abandoned case, the case studies mounted to 46 interviews.

The principal criterion for determining whom to interview was the level of knowledge of and involvement in the subject area of the individuals.[73] Within the focal companies several people were interviewed. Snowball sampling was used as a technique for identifying and gaining access to the appropriate people to interview within each focal company. Initially, a relationship was established with an individual who would act as the main contact person. This individual was briefed about the research project through a written project summary and an initial 'set-up' meeting. He/she was either the first person contacted or someone identified by the initial point of contact. For example, in the case of the focal company AutoEngineer, the initial point of contact was the Managing Director, who appointed the Manufacturing Director as the main contact. However, after some time he appointed another person, the Business Unit Director, as the main (and final) contact for the research project. The researcher and the main contact person jointly performed the identification of further interviewees.

The process and criteria for the choice of external actors to interview followed a similar snowball methodology. Either the main contacts or other focal company individuals identified relevant customers and suppliers for interview. The appropriateness of each of these was then discussed with the researcher, considering their level of involvement and collaboration in the innovation project, and their perceived willingness to partake in an interview. As interviews often concerned issues of a confidential or political nature all interviewees were promised confidentiality; only by promising and keeping confidentiality was it possible to conduct the interviews (hence all names being concealed). The promise of confidentiality enabled many sensitive and confidential issues to be revealed, in the majority of the cases even with the tape recorder running. Only a few times did respondents ask for the tape recorder to be switched off for a period of time. The formation of trust between the researcher and respondents was important to reassure respondents of the purpose and use of the information and insights they provided. Some respondents were highly concerned about confidentiality, often because of the imminent project launch and the risk of leakage, which in itself was interesting given the subject of inquiry. For example, in one case the focal company contact person had persuaded the customer to participate in the interview at the focal company's premises, but had warned that he would probably not want to even reveal the company for which he was working. Initial explanations and assurances, however, persuaded the respondent to 'open up'.

Each interview was of a duration of app. one and a half to two hours, although some were as long as three hours. The research instruments were semi-structured interview guides structured around the conceptual framework, leaving space for discussions, encouraging examples and teasing out critical incidents.

As a basis for discussing the activities an initial interview, using Interview Guide One, was held with the main contacts within each focal company; this concerned the particular context, or essential company, market and supply characteristics. This interview guide is appended in Appendix B. Network mapping was conducted to identify the major actors involved in the innovation project and their respective components and technologies. The emphasis on understanding these complex contextual factors was critical due to the critical realist approach. Finally, a discussion on how the respondents believed the activities could be employed to improve their management of innovation projects was undertaken. This was an attempt to move from the discussion of the past and present to a more future and improvement-orientated focus. This was seen as a visionary technique to explore how the respondents felt they could better apply the collaboration activities within their specific circumstances, and a way to discuss the potential usefulness of the collaboration activities in a specific set of circumstances.

On the basis of the initial contextually focused interview the next round of interviews, using Interview Guide Two, focused on the set of collaboration activities and how each activity was constrained and/or enabled by the network. This is appended in Appendix C. In some cases the main contact was interviewed once more for this purpose, however, in general the second round of interviews sought to collect data from other key informants within the focal companies.

[73] See Appendix H for an overview of respondents.

Following examination of the focal firm, the case studies continued with confidential interviews with a set of suppliers and, in three of four cases, the main customer. The focal firm facilitated external interviews, or what can be described as 'snowball' sampling. Using Interview Guides Three and Four (Appendices D and E), the subject of those interviews was the set of collaboration activities and network effects, as perceived by actors on 'the other side of the relationship', which was essential to gain a critical understanding of the collaboration activities. Furthermore, the interviews with external actors discussed how the activities related to the focal firm's innovation project were performed in other parts of the network. In other words, the discussion of the collaboration activities was two-directional: 1) discussions between the focal firm and the external actor being interviewed and 2) discussions between the external actor and its own relationships 'further away' from the focal firm. As part of the exercise external actors were asked to identify the network actors as seen from their network position. As in the focal firm interviews, interviews with external actors concluded with a brief discussion of how respondents believed collaboration activities could be improved.[74]

The interview style was conversational rather than treating respondents as objects of research. The interview guides acted as a loose rather than rigid structure, so discussions often took unexpected turns. Whereas this presented a danger that the data might not be relevant and required an element of control on behalf of the researcher, such discussions also provided rich insights that often later proved to be valuable.

It was originally planned to combine face-to-face interviews with questionnaires to a wider group of employees from key departments related to a specific collaboration project within each focal firm thereby triangulating the data as a method to increase the reliability and validity of the findings (Ramsay, 1998). However, the pilot case showed that it was problematic to gain access to and persuade potential respondents to complete a questionnaire. Hence it was decided instead to include a set of structured performance assessment questions as part of the interviews.

In addition to formal interviews, information has been acquired, which can best be characterised as 'informational residue' (Lincoln and Guba, 1985). Informational

[74] This aspect of the interview also provided an incentive for external actors to participate in interviews, as they could benefit from the interview if the focal firm decided to follow-up on any discussions

residue is information that accumulates without intent on the part of either the investigator or the respondent (*ibid.*, p. 279). Such informational residue was accumulated in all four case studies (and indeed prior to the four case studies during early unsuccessful case facilitation). An example of informational residue acquired during the case studies related to an insight gained during lunch with two respondents in one case during which they revealed that the culture of the focal company was highly technical, not least because of the personal academic background of the Chairman. This insight informed subsequent interpretation of reasons for the relatively low levels of collaboration with some network actors. Such informational residue proved to be very useful and whereas it was rarely a planned acquisition the researcher sought to be alert and receptive to such information.

Finally, relevant company reports and other secondary documentation were collected. These provided supplementary introductory information to companies and their official practices. Company and industry web sites were consulted prior to interviews as a *modus operandi*. All of the companies interviewed had company web sites and although many of these were superficial and promotional, and hence biased, many included links to articles that had been written by, for example, industry analysts. Some companies even had web sites documenting their internal managerial processes and systems, and although these were generally idealistic they still helped to grasp and follow conversations and interpret data. This was particularly useful in the case of the Interception Gateway project, which had to be understood in the context of, for example, 3G telecommunications developments and requirements.

5.5. Time Horizons

The question of time horizon is important in research, which addresses dynamic topics such as innovation, change processes, and networks. The ideal time horizon would have been longitudinal, for example following the whole length a new product development project. However, it was decided against such a strategy due to the implications on the length of time of such a strategy in relation to the prescribed time of the thesis. Hence, it was decided that the cases should be cross-sectional. Each case study spanned

concerning improvements.

approximately four to eight months, which allowed for the tracking of some developments although too limited to make the study truly longitudinal.

Another temporal issue concerned the ideal stage of development of chosen projects. It was decided to concentrate on projects that were approaching launch or had recently been launched. This was important to make sure that the project experience was fresh in the respondent's memory, especially problems and conflicts as post-rationalisation would otherwise be likely. It was important that the projects be close to launch, as otherwise respondents would not have undergone all the project phases, including the final often precarious points in a project. Moreover, the ambition to evaluate the perceived performance of the project would be impossible unless the project was nearing its end. Several potential cases were investigated, including initial exploratory interviews, only to find that these had to be terminated, as the projects had not progressed sufficiently.

5.6. Analysing and Interpreting Data

5.6.1. Analytic Strategy and Technique

The analytic strategy adopted in this thesis was to seek to relate data to the research questions through the conceptual framework. The analytic technique adopted to achieve the best possible fit between research questions and the data can be described as pattern matching (Yin, 1989), comparing the case study results with the theoretical propositions or research questions. Given the focus on understanding and explanation there was also an element of what Yin terms 'explanation building' although no formal stipulation of causal links was developed. Rather, the critical realist orientation and abductive approach meant that the analysis sought to uncover combinations of contingencies, or contextual factors, by continuously reflecting on the data and revisiting the literature.

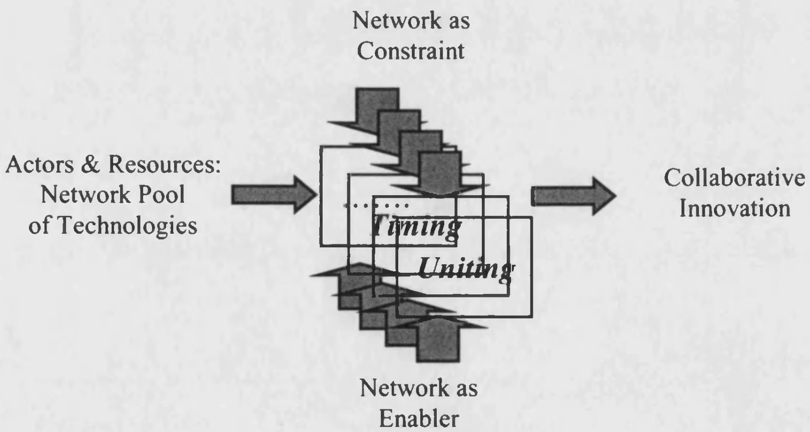
5.6.2. Intra-Case Analysis

In the majority of cases the interviews were tape-recorded. In these cases interview data were transcribed or thoroughly summarised. In the cases where recording was not possible, usually due to respondent's concerns about being recorded or a noisy meeting venue, notes were taken during and after the interviews and summaries written as soon as possible whilst the interview was still fresh in memory. Transcripts were initially produced by the researcher, later by professional transcribers recommended by CRiSPS. Early transcripts were thoroughly checked for correctness and any mistakes, such as misunderstood terminology, were discussed with the transcribers to avoid future mistakes.

Transcripts or summaries were read and annotated to match data with the conceptual framework i.e. collaboration activities and different forms of network effect. The annotation used in this study would be described by some as first level coding (e.g. Miles and Huberman, 1984; Robson, 1997), although the use of a formally structured coding framework was restricted to the collaboration activities and network effects, as discussed below. In addition, contextual factors and emerging themes raised by the respondents were identified. Data from the interviews were then complemented with the documentary data and any informational residue.

The set of collaboration activities and the conceptualised forms of network effect were captured in the conceptual framework, which provided a conceptual structure guiding the further content analysis. The analysis followed the logic illustrated in the Figure 20.

Figure 20. A Framework of Analysis



Matrices were constructed and used as tools, or coding frameworks, for analysing network effects on each collaboration activity, on the basis of the method identified in Figure 20. The matrices were sorted by interpretations of each activity and network effects across respondents, which were extracted, interpreted and summarised from the annotated transcripts. Different forms of network effect were highlighted in the matrices by the use of different types of bullet. Thus, the matrices were what Miles and Huberman describe as 'role-ordered', but also included elements of their 'effects matrix' (1984). Two types of matrix were constructed: firstly focal actor interpretations and secondly 'external' actor interpretations. These are appended in Appendix F. Meta matrices captured the overall pattern of activities and network effects, thus representing what could be seen as the aggregated picture of the underlying reality.

Important contextual factors were derived from the list of contextual questions that formed a large part of the first focal firm interview guide and the first parts of customer and supplier interviews. Contextual factors included project details, including levels and forms of innovation represented in the project, product characteristics, firm characteristics, and network characteristics. The latter was analysed by means of network mapping, drawing a picture of the network in conjunction with the respondent, as an introductory part of each interview. Network maps were then refined using a PC after interviews, and validated with respondents as interviews progressed within each case. Matrices similar to those developed for collaboration activities and network effects, were constructed to capture different interpretations of important contextual factors.

Quotes were extracted from transcripts to provide illustrations of important issues or themes. Only those quotes that were viewed as representative of the case as a whole were included. This was established through comparison with the overall data set. However, some quotes have been included to illustrate particular points of view. Potential quotes from respondents that were seen as peculiar were excluded.

5.6.3. Inter-Case Analysis

The purpose of inter- or cross-case comparison and analysis was not least to provide external validation (see the following section) of the individual case study findings (Eisenhardt, 1989). Hence, patterns were to be identified in terms of commonalities and divergences across the individual cases. These patterns were identified through cross-case comparison meta matrices (Miles and Huberman, 1984), which focused on the collaboration activities and network effects, again highlighting the latter by the use of different types of bullet (see Appendix G). The patterns identified through the meta matrices had to be related back to the contextual characteristics that had emerged from each case. Seeking out contrasts (Miles and Huberman, 1994) was a useful tactic in developing an understanding of the particularities of each case. This analysis process led the way for identifying and revealing the particular contingencies of each case and how these, or a particular set of these, could help to elucidate particular patterns of collaboration activities and network effects.

The critical realist approach implied a search for the more objective reality underlying the perceived and more subjective reality. Matrices provided a means to uncover 'reality' by enabling an aggregated picture of intra- and inter-company interpretations. Patterns emerged that revealed both differences and similarities across respondents. When combined with the contextual analysis, which provided understanding of e.g. companies, relationships and individuals, it became possible to build explanations through identification of patterns in answers and views. Following the critical realist perspective, the analysis did not seek to identify simply causal relationships; the analysis sought to build understanding and explanation through the 'causal powers' represented by the contextual, or contingent, factors captured.

Although there was an attempt to make the process of analysis and interpretation systematic and logical it was by no means linear and ordered. Instead, it was an iterative and sometimes messy process of trial and error. Interview transcripts provided the main source of data but these had to be complemented with, and interpreted in the light of, documentary data, informational residue as well as the researcher's own experience, knowledge and beliefs. Transcripts were read and re-read, and interpretations revisited following new information and emerging realisations. The final stage of data collection and analysis was obtaining feedback on the draft findings, as described in the following section.

5.7. Validating Findings: 'Testing' Research Credibility

Yin (1989) identifies four criteria, or tests, used to establish the credibility of any case study research – construct validity, internal validity, external validity and reliability.[75]

[75] There are discussions in the methodology literature regarding the applicability of such concepts as 'internal validity' in the context of qualitative research. For example, Lincoln and Guba (1985) make a case for four alternative criteria: credibility, transferability, dependability, and confirmability. I decided

5.7.1. Construct Validity

Robson (1997 p. 68) defines the principle of construct validity as "does it measure what you think it measures?" Validity is about the truth and 'goodness' of the findings. Yin has suggested three approaches to ensuring construct validity (1989), which were adopted in this thesis. The first of these was to collect data from multiple sources. Primary data were collected through interviews, whilst secondary data were collected via company reports and internal documentation in addition to desk research. The second was to have case study reports read by key respondents, and follow-up meetings to discuss and validate the observations and conclusions made in reports that had been forwarded; this is what Reason and Rowan refer to as 'respondent validation' (1981). Respondents were asked to comment on the description of the project and level of innovation identified, the companies involved and the network map, technology issues, collaboration activities, whether anything had been misunderstood, missed out etc.. Furthermore, they were asked to comment on whether in their opinion any activities should have been added or excluded, and whether they agreed with or wanted to add anything to report conclusions. All respondents asked to comment on reports were of the opinion that the reports were accurate and that the analysis was very perceptive. Some had evidently read the report in more detail than others and were keener to ensure that all details and conclusions were correct.[76]

The third approach was to allow an external observer "to follow the derivation of any evidence from initial research questions to ultimate case study conclusions" (Yin 1989, p. 98). The project supervisor primarily filled this role, but feedback from colleagues within CRiSPS and the University of Bath, in addition to my wife, who has been undertaking a Ph.D. study into a related area of research, also constituted valuable sources of such validation.

5.7.2. Internal Validity

Internal validity is a question of consistency in content between a nominal and an operational level (Andersen and Gamdrup, 1990). It is a matter of measuring what one

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that Yin's criteria are appropriate given my approach and research strategy, and in any case are comparable with those of e.g. Lincoln and Guba (*ibid.*).

[76] In one case the main contact held a doctorate and thus had a natural interest in the process of research and in accuracy of findings and conclusions.

intends to measure, in positivist terms, or gaining full access to the knowledge and meanings of informants (Easterby-Smith *et al*, 1996). Sykes describes internal validity as the internal coherence of the findings – the snugness of the fit between the data and the findings or conclusions (1991, p. 10). The purpose of the exploratory mini-survey and the pilot case study was partly to ensure such internal validity by fine-tuning the research instruments, ensuring appropriate 'operationalisation' of concepts and constructs. Furthermore, discussions with supervisor and other researchers in the field, for example within CRiSPS, helped to improve the internal validity of conclusions in relation to the data.

5.7.3. External Validity

The question of external validity depends greatly on the philosophical stance. To researchers leaning towards positivism external validation concerns generalisability of findings (see for example Silverman, 2000), however, to researchers leaning towards phenomenology external validation concerns the generalisability of conceptual structures. Yin (1989) suggests that a case study must not be regarded as a 'sample', and that the investigator's goal is to expand and generalise theories. This approach is also known as analytic generalisation.

The choice of four case studies conducted across two industries was motivated by a wish to maintain external validity and analytic generalisation in particular. It was the reason for not conducting one very extensive case study, as advocated by e.g. Easton (1998) and Dubois and Gadde (2002), as the risk of such a strategy would be the utter peculiarity of any one case, with little relevance to any other cases. The external validity provided by four cases constitutes a first step towards replication and thus testing of the findings, in different intrinsic and extrinsic contingencies (Tsang and Kwan, 1999). Comparisons of the empirical findings with the literature was the final step in trying to externally validate the findings, seeking similarities and inconsistencies with the extant literature (Eisenhardt, 1989).

5.7.4. Reliability

Reliability concerns the 'repeatability' or consistency of findings (Sykes, 1991).[77] Kirkeby (1990) distinguishes between intra-subjective and inter-subjective reliability, where the former would require the same researcher to reach the same findings if the study were repeated, whereas the latter would require another researcher to reach the same findings. Frequent discussions with colleagues working in the same or a related field of study have sought to increase the reliability of the findings from this thesis. It was a deliberate decision to position myself in two different research communities, IMP and IPSERA, and it has also reflected an attempt to avoid reliability problems. Both IMP and IPSERA are concerned with the study of very similar phenomena, customer-supplier relationships and networks, albeit often from different perspectives and research paradigms. Any researcher who purely relates his or her research to any one research community and paradigm arguably runs the risk of a myopic understanding of the research.[78]

5.8. Conclusions

This chapter has discussed some philosophical and methodological issues in connection with the main empirical part of the thesis. I commenced with a discussion of the three philosophies of positivism, phenomenology and critical realism, evidence of which can be found in previous innovation and networks research. I argued that a positivist philosophy is inappropriate for this inquiry into collaborative innovation in networks, because it is characterised by systems that are by definition open. Such openness is evident not least in my focus on *inter*-organisational relationships and *connectedness*. Any attempt to isolate the system under scrutiny in an attempt to provide explanation through simple law like causal relationships could therefore be seen as misguided. The phenomenological philosophy is often adopted by researchers in social sciences to counter many of the disadvantages of positivism, most notably through its premise of a socially constructed rather than objective reality. In contrast to positivistic research, phenomenological research tends to be predominantly qualitative in nature to allow for a deeper understanding of contextual factors. However, I observed that the danger with

[77] The problem of reliability was discussed in the previous section 5.1.

[78] Conversely, presenting one's findings to a 'foreign' audience can sometimes be problematic as I experienced at a conference recently when one person cried 'There are no networks!' Reverse statements such as 'There are no supply chains' may be experienced in 'the other camp'.

a phenomenological orientation is that the philosophical position adopted dominates the research findings and disregards any other reality than the one constructed by the researcher (Kwan and Tsang, 2001). The researcher's subjective reality therefore becomes perfectly satisfactory, which thus divorces the notion of reality from subjectivity. I reached the conclusion that the phenomenological philosophy for these reasons did not offer a satisfactory solution. Instead a critical realist philosophy as advocated by Easton (1998, 2002) and underpinned by e.g. Bhaskar (1978) was chosen as the most appropriate for the subject of inquiry. The concept of 'reality' within critical realism, however, does not concern relationships between discrete events (cause and effect), but 'causal powers'. Extrinsic and intrinsic contingencies, rather than simple causality identified through correlation, are used to provide explanations through such causal powers. Thus, I seek to highlight a variety of complex contingencies, or contextual factors, which appear to influence the patterns in the findings. I also highlighted the notion of replicability in critical realist research. However, I stated that I perceive this thesis as but a part of an overall research agenda into the problems of managing collaborative innovation in networks. Therefore, further evaluation and replication of the findings and conclusions will be required to continue the research in the search for the underlying, but by no means ultimate, truth.

Case studies were adopted as the most appropriate research strategy due to the complexity of the phenomena of the inquiry; case studies allow identification of 'causal powers' and complex contingencies (Easton, 1998). It has been explained how an exploratory mini-survey helped to form the conceptual structure and refine research questions. It has also been explained that the unit of analysis needs to be considered at three levels; the focus is on relationships, new product development projects, and focal firm networks. It is important to recognise that whereas there are inevitably disadvantages of such foci, my judgement is that these are outweighed by considerable advantages. The four case studies were introduced and justification for why those particular cases were chosen was provided. Strategies, tactics and methods of analysing and interpreting the case study data were discussed. It was highlighted that although attempts have been made to ensure that this process was systematic it was by no means a linear ordered process. Nevertheless, I believe that the results of the four cases show a satisfactory degree of validity and reliability.

The next three chapters of the thesis present and discuss the empirical findings about collaborative innovation and different forms of network effect. The following chapter presents the first part of this: the exploratory mini-survey.

CHAPTER SIX: FINDINGS FROM AN EXPLORATORY MINI-SURVEY

6.0. Introduction

This chapter reports on the findings from the exploratory mini-survey, which constituted the first stage of empirical data collection of the thesis: exploratory interviews with five focal companies across two industries.[79] The purpose of the mini-survey was: 1) to explore the usefulness of the initial set of collaboration activities emerging from the research; 2) to explore how the management of the activities may be constrained and/or enabled by the surrounding network; 3) to explore possible differences in the management of collaboration activities and network effects across different circumstances.

The first section of the chapter introduces the five projects investigated to provide a basic understanding of the specific contingencies of each case. Thereby, the patterns of collaboration activities and network effects across the five projects can more easily be appreciated. The second section explores the patterns of the set of collaboration activities and apparent network enabling and constraining effects across the five projects.[80] The conclusion discusses the theoretical and methodological lessons from the study and the implications of these lessons on the main empirical part of the data collection: the four in-depth case studies.

6.1. Five Development Projects

As explained in Chapter Four it was decided to focus on the automotive and pharmaceutical industries, because of their relative importance to British (and continental European) industry and because existing research, from which the collaboration activities had been identified, often include these two industries, yet have not fully considered the problems and opportunities offered by the surrounding network.

[79] The findings from the exploratory mini-survey were also discussed in Johnsen and Ford (2000).

[80] The term 'case' in this chapter is not used to imply that the five interviews that were conducted were 'in-depth cases studies'. It is simply used to refer to each of the projects that were examined as part of the exploratory mini-survey.

Within these two industries it was decided to include projects of different scales (e.g. in terms of intended production volume and value) and focal firms of a variety of sizes, to explore different forms of focal firm network behaviour in different circumstances.[81]

This section introduces the five projects investigated to provide an understanding of the contextual settings of each of the cases and thereby enable the later discussion of illusive patterns of collaboration activities and network effects across the five projects.

6.1.1. Viral-Drug Development Project

The viral drug development project began in 1992 as a concept of a vaccine to target a common viral infection. The founder of the focal company 'Bio-Pharm', a university Professor, generated the initial idea for the technology, but Bio-Pharm quickly became involved and obtained a license from the university. In addition to the relationships between the focal company and various academic parties, a major pharmaceutical company became involved to assume the production, supply and marketing responsibility once the drug had been sufficiently developed and tested; this required process and marketing capabilities and technologies that Bio-Pharm did not possess on its own. At the time of data collection the pharmaceutical company marketed comparable products treating the virus, however, its drugs did not eliminate the cause of the virus. The relationship between the focal company and the pharmaceutical company, which had an official status as 'corporate partnership', although essentially a licensing agreement, began when the drug development was reaching clinical trials. It took some time to develop the technology for the particular drug application, but Bio-Pharm had been able to use it as a delivery system in other drugs as well, so the project was essentially a platform development. At the time of data collection the project was entering Phase Two trials testing with a small selection of human patients.[82] It was due to be launched in 2003.

The project was regarded as highly important to Bio-Pharm. The corporate partnership with the pharmaceutical company was significant not least from a financial point of view due to large milestone fees. It was also important because it constituted a platform technology on which a number of other products could potentially be based. Hence, the

[81] Please return to Chapter Five for further details of selection criteria in the exploratory mini-survey.
[82] Phase Three refers to testing on a large number of people with disease.

project represented both a product and a product technological innovation. Due to its carrying capacity it could be used, for example, to target cancer tumours or Parkinson's disease. Patents had been filed, as Bio-Pharm was highly protective of its intellectual property rights.

6.1.2. Drug Development Project

The product in focus of this study was a compound drug that was launched shortly before the interview in 1999. It was licensed by the focal company, Pharma, from another pharmaceutical company, at which time only a molecule had been designed. The process for manufacturing at a large scale in a safe manner still remained to be developed. The main external parties involved in the project were the licensing partner and a number of strategic suppliers of active ingredients. Furthermore, at Phase Two hospitals and patient care groups became involved in clinical trials.

The project presented a challenge to the actors involved due to the potentially hazardous manufacturing process. Therefore, following Phase Two manufacturing processes had to be developed in tandem with the development of the product. Most of these processes already existed, but the drug necessitated a new combination of these. The innovation within the project was thus mainly in process technology, in addition to the new product; as the drug represented Pharma intellectual property it was patented for protection. The focal company in this case, the drug manufacturer, appeared to attempt to exert some degree of influence and control over the network, particularly in relation to its supplier network.

6.1.3. AJP8 Engine Development Project[83]

Around 1994 the focal company in this case, TVR Engineering, decided to set out on a seemingly impossible task: to develop its own engine: the AJP8 eight cylinder engine. This was a response to fears that Rover, TVR's engine supplier, would be unwilling to supply engines to TVR in the near future, because its new corporate parent at the time, BMW, marketed competitive products. Developing its own engines helped TVR to progress as a company and limit its dependency on Rover whose engine manufacturing

[83] As the focal company TVR approved that the information revealed during the interview did not have to remain confidential the real names of the actors involved are used.

was declining as it became transferred to BMW in Germany. The project represented a significant innovation to TVR and involved application of materials (such as crank shaft materials) that were new, at least to TVR. The AJP8 engine was successfully completed and launched in the 'Cerbera' in 1997.[84]

The initial engine development was managed by a technical consultancy company, however, TVR began to view the relationship as too much of a one-way street where it supplied more knowledge to the consultancy than *vice versa*. So, it was a conflict of interest that put an end to that relationship. The AJP8 project enabled TVR to develop its later six cylinder engines without relying on external consultants.

The engine development project was by no means a case of strategic or controlled network co-ordination or management, indeed the case seemed to be predominantly characterised by a 'coping' approach. The management took place within dyadic relationships and resources and technologies in the wider network were accessed through extensive networking.

6.1.4. Exhaust System Development Project

The project in focus of this case concerned a new generation of exhaust systems, which used a two-stage catalyst to conform to EEC emission requirements. The focal company in the case was a joint venture between a major British automotive parts supplier and a German equivalent. Neither joint venture party possessed all the required competencies in-house, so the joint venture was established to develop the new generation of exhaust systems and to share the costs and risks of the R&D for mutual benefit. The joint venture was initiated approximately one year prior to the interview in 1999 and was to be launched, or fitted to cars, in late 2000.

The initiating factor for the project was EEC emissions requirements, which spurred vehicle manufacturers and component suppliers into developing new technology to meet the new stringent requirements. The main customers of the British and German component suppliers had therefore initiated the development and one German vehicle

[84] The two or three years between the interview and project launch is inevitably a limitation of the findings, which may affect validity and reliability due to, for example, distortion of the memory of the respondent. Nevertheless, the fact that this was the focal company's largest and most significant engine

manufacturer played a lead role in the design. The product technology was proprietary and thus protected, although the respondent recognised that the whole industry had to develop similar technologies to meet the same emission requirements. The innovation in this case thus concerned the new product technology being developed to meet the new EEC standards.

6.1.5. Car Development Project

The project in the final case concerned the development of a new car concept, which began in 1995.[85] Launched in 1997 the car sought to combine performance, design, and affordability in a new way, challenging the assumptions of the traditional market segmentation. The car also introduced several new product technologies, enabling new performance capabilities. The car represented a significant innovation to the focal company, the vehicle manufacturer. Not only was it based on a different vehicle platform from what the company normally used, several features of which were patented, but it was also going to be significantly higher volume than what the company was used to producing and supplying.

For the focal company, the vehicle manufacturer, the project also brought about an attempt to move away from the dual sourcing strategy and relatively arms-length supplier relationships of the past; an overall aim was to improve supplier involvement in product development.[86] Moreover, a group of dealers representing nation-wide dealerships were involved in the project by providing product feedback, for example on design and functionality, and taking part in project team discussions of production and supply issues. Hence, of all the five projects explored during this stage of the empirical data collection this project was at the largest scale and appeared to be characterised by attempts by the focal company, the vehicle manufacturer, to exert some degree of influence and control over the network.

development project to date meant that the experience was still fresh in the memory of the respondent at the time of the interview.

[85] The notion of a truly 'new' and innovative car is arguably problematic in an industry as mature as the automotive.

[86] About 180 direct, or 'first tier', suppliers and at least 400 or 500 indirect, or 'second tier, suppliers were involved in the project.

6.1.6. Some Key Contextual Differences

The introduction to the five projects examined as part of the exploratory mini-survey reveals a variety of different contingencies. Although the selection was divided into two industries it is clear that even within the chosen industries the projects differed substantially. Some represented highly formalised and organised projects, whereas others appeared to have been much more loosely organised. This seemed to follow the pattern of the size of the focal companies involved and the volume and value of the projects. Importantly, the nature of the projects varied significantly in terms of the nature of the unit of analysis; in some cases the development of end or assembled products provided the focus, in other cases the focus was on the development of component parts and/or product technology of end products. The apparent relationships and patterns between these contingencies and the collaboration activities and network effects are to be discussed in the final part of this chapter.

6.2. Observations on Collaboration Activities Across the Five Projects

This section presents the findings on each activity from across the five projects. It briefly describes the nature of each activity, exploring any intriguing issues, and identifies the apparent constraining and/or enabling network effects.

The initial set of activities formed the heart of the data collection at the exploratory stage of the research. As discussed in Chapter Four these were:

- *Identifying/Selecting*
- *Timing*
- *Mobilising*
- *Informing*
- *Synchronising*
- *Assigning human resources*
- *Co-ordinating*

The mini-survey did not attempt to test the significance of network effects, but rather to evolve an understanding of how network effects might reveal themselves in different ways within each of the initial collaboration activities. Therefore, it did not make sense to try to 'operationalise' network effects in too much detail. It was decided merely to translate network effects into interview language by referring to the enabling and constraining effects of 'third party' relationships (see Appendix A for the interview guide).

Table 15 provides an overview of the findings on each collaboration activity across all five focal companies interviewed, including the different ways in which the activities appeared to be affected by the network.

Table 15: Collaboration Activities and Network Effects Across Five Projects

Projects / Activities	Car Engine Development	Exhaust System Development	Car Development	Viral-Drug Development	Drug Development
Identifying/ Selecting	· Emergent and informal process: companies 'accidentally' come together · Main route of identifying suppliers is through suppliers and (technical) consultants suggesting suppliers. May also obtain better quote through other suppliers (1st tier) having long rels. with (2nd tier) suppliers · Process often hindered by 3rd party rels. when suspecting that FC components/technologies would be offered to competitors	· Historical suppliers involved in project - set of selection criteria e.g. cost, technology, quality, service: different factors qualify different suppliers · Process probably not hindered by 3rd party rels. · Process probably enabled by suppliers believing they would get additional business	· Structured supplier nomination process: long term partners (suppliers) become preferred choice at nomination stage - but FC also wants some competition · Supplier selection related to long term strategy and wish to maintain local supply base: 3rd party constraints not visible · Process enabled by supplier's other rels., as client list is reference of experience and capability	· A process of going out, trying to make parties interested · Few constraints due to 3rd party rels., but conflicts of interest when selecting consultants (and occasionally clinicians) as they may be working for competitors · Clinicians, universities and consultants, become involved because they have interacted with other people - by reputation or word of mouth.	· FC sourcing team identify suitable suppliers for new projects through a model of suppliers' competencies, providing structured mechanisms and criteria: almost all strategic suppliers used to be raw material supplies · Process not constrained by suppliers having other rels., as long as they can allocate sufficient resource and responsiveness. FC encourages suppliers to have other rels. as this is a source of knowledge
Timing	· No formal framework, but large no. of actors involved early. · Process not affected by 3rd party rels.: in or out. Some suppliers involved later as FC learn about them through other suppliers.	· Suppliers became involved during detail engineering · 3rd party rels. would not have influenced timing	· Different suppliers get involved at different stages: no hard rules	· Corporate partner/customer gets involved later on, when FC has developed basic technology	· Suppliers become involved as early as possible: Phase 1 or 2 regardless of 3rd parties. Timing affected by time and regulatory constraints.
Mobilising	· Process enabled by FC's reputation and when FC's business is large part of suppliers' total business. However many large companies do not want to become involved with a small company like FC · Motivation and commitment of consultants and some suppliers decrease over time as they develop other client relations	· Some partners involved in FC's improvement programme, others became involved as they had unique technologies · 3rd party rel. probably did not influence mobilisation, although FC may ask questions of suppliers other customers/commitments	· Majority of suppliers existing suppliers for other products: incremental business · Do not know of 3rd party effect	· Corporate partner and regulatory authorities mobilised by penetrating to their highest possible position	· FC applies risk & benefit sharing arrangements once process is fixed. FC generally ensure suppliers are involved throughout PLC · Once involved suppliers not difficult to motivate
Assigning	· Limited and informal: FC likes to keep everything under control and close to the company · Some suppliers allowed to use FC's testing equipment on site - even if for another company, because FC will benefit eventually	· Would have been a person or team of [supplier] people allocated to project · Doubt the process would be constrained by 3rd party rels.	· Resident engineers brought in to FC · No perception of difficulties due to 3rd party rels., but security videos and security discussions at conferences	· Limited, some on development side: e.g. academics may come in for short time or vice versa (contract basis). Also regular meetings and discussions. · Confidentiality agreements help to segment knowledge	· Extensive during validation: team spend 1 month with suppliers ensuring manu. processes are OK. Suppliers may transfer people to FC when developing novel innovation · Not constrained by 3rd party rels.: controlled by trust and secrecy agreements
Informing	· Informal process: mostly phone, e-mail and meetings (some suppliers require written documents) · Race car customers lease engines and provide feed-back on problems and improvements (data logging) · Loss of sensitive knowledge and info. a major concern when technology can be copied by competitors: mostly governed by trust, but sometimes confidentiality agreements	· Clear communication through improvement process i.e. Gantt charts, time scales, milestones, and KPIs · Info. and knowledge constrained by suppliers' agreements with other customers - parties would keep knowledge separate and respect confidentiality · Contracts widely used	· One-to-one communication between key supplier and FC people + supplier conferences, logistics focused workshops and other programmes · FC guidelines on security e.g. re. leaving parts exposed or info. on notice boards. (videos and security conferences). Suppliers informed on 'need to know basis' · Dealer council provide product, potential markets and dealership capacity feed-back	· Confidentiality agreements help to keep info. and knowledge segmented · Communication of forecast info. with corporate partner	· Little leakage of knowledge: industry a fairly closely-knit community. May be a problem when dealing with countries that have limited regard to IPR
Synchronising	· Very limited · Suppliers may have to synchronise amongst themselves	· Synchronisation of EDI and e-mail systems, data transfer, technical specs, paletisation, and possibly transport: would be resolved at this stage (prior to production) · Would probably not have been constrained by 3rd party rels.	· Milestones synchronised and suppliers required to perform to various standards e.g. EDI, ISO9000 and technical standards · Different EDI standards for different automotive companies (e.g. multi-national suppliers): standards have to conform to FC	· Agreed processes and work undertaken to agreed timetables for certain stages and milestones have to be synchronised. Contracts establishing IPR · Conflicts of interest as people work for different people at the same time: different priorities	· Systems are synchronised. Not imposed by FC, but suppliers increasingly adopt similar standards e.g. SAP or e-mail · FC encourage suppliers to adopt similar principles rather than mechanisms as suppliers have many customers
Co-ordinating	· No formal co-ordination structure: FC initiate and rely on suppliers to unite themselves (suppliers tend to know each other very well anyway) · FC do not rely on modular suppliers: believe design becomes conservative. Only viewed as relevant for [proprietary] suppliers	· FC would encourage suppliers to unite as a group across chains and tiers - unsure about FC's specific role, but FC try to bring 1st tier suppliers together to ensure parts fit together	· Suppliers encouraged to unite when involved in same mechanisms/systems. Modular suppliers responsible for co-ordination · 1st tier suppliers left to co-ordinate across tiers (only exceptionally specified by FC)	· FC's role is to manage all rels.. Some 'round tables' with several partners. · Problem of divorcing discussions: possible to discuss one thing with a person at one meeting, which cannot be used at other meetings with same person: controlled by confidentiality agreements	· Strategic suppliers generally supply all FC sites, hence co-ordination is important to avoid overlapping: team responsibility

6.2.1. Identifying/Selecting

The degree of formality in the identification/selection process varied across the five cases from the one extreme of companies 'coming together' more or less accidentally, to a very structured and seemingly rational supplier nomination process. In the case of customer-supplier relationships, large powerful customers, such as the vehicle manufacturer in the car development project and the large pharmaceutical company, to a large extent chose their suppliers and submitted these to complex and demanding selection procedures. Often a sourcing team would identify suitable supplies for new projects, using a model of structured mechanisms and selection criteria. In other cases customer companies were simply not in a position where they could dictate with whom to work. For example, the TVR respondent believed that many potential collaborators would not want to become involved with a small company such as TVR. Moreover, as the respondent in the exhaust development project stated:

> *Some people probably would……say we chose our suppliers and would not like to acknowledge that it is [vehicle manufacturer] driven.*

Hence, although people may often believe, due to ontological assumptions, that they are in control of a rational selection process, the underlying reality may be different. It was not always a case of the customers simply identifying and selecting with whom to collaborate; the process was interactive to different degrees, depending on the circumstances.

In terms of network effects there was evidence of extensive networking in several projects, but perhaps so mostly in the case of the engine development project:

> *Our budget was very low which forced us to the bottom end of the consultancy market. So we looked at the small people, so you tend to get less good people. E.g. with some of the casting work we had done, one supplier quoted us, but he was too expensive. We then subsequently used them through another supplier, which was doing machining work for us and used them a lot and then got a better quote. We have then dealt with them ever since through that 3rd party. It's another funny relationship where we gained from our relationship with this machinist because he managed to source us good quality castings at good prices which we ourselves couldn't do. And the casting company was*

> *happy because they could deal with a known customer. You get a lot of that.* (TVR Chief Engine Designer)

Indeed, in the case of the engine development project most contacts were made through network connections. However, in the case of the car engine development project, TVR expressed a concern that third party relationships might also constrain the process of selecting suppliers when suspecting that TVR's technologies would be offered to competitors:

> *[It happened with] a company making e.g. crankshafts for us. I stopped using him for the kind of profiles we had spend a lot of time designing in house because I knew he would offer them to other customers and we wanted to keep that information to ourselves. We stopped dealing with him for that particular reason, but we still deal with him for components where we are not worried about that.* (TVR Chief Engine Designer)

The respondent from the viral drug development project highlighted that such conflict of interest might particularly concern consultants as these would often consult for a range of companies.

Conversely, third party relationships, often influenced the selection process positively as suppliers would use impressive lists of their customers to provide reference points of experience and capability. Indeed, relationships with consultants illustrated the paradoxical nature of relationships. On the one hand it was a cause of concern that consultants might transfer knowledge to competitors; on the other hand it was generally recognised that they possessed, and therefore offered, their knowledge as a result of having worked for other clients.

Finally, the history of supplier relationships seemed to be important in most cases. The view was often expressed that suppliers could not simply be looked up in a directory.

6.2.2. Timing

The timing of the moment of involvement of suppliers did not appear to be influenced by third party relationships. In the case of the viral-drug development project, the corporate partner of the focal company 'Bio-Pharm', which was the main customer eventually to license the product, became involved with 'Bio-Pharm' at a later stage. The corporate partner became involved late in the project to ensure that sufficient clinical testing had been successfully completed and thus that the product potential was sufficiently strong. The particular pharmaceutical context of very long development times and extensive product testing seemed to cause the difference in this case as well as the fact that this related to a relationship based upon a licensing arrangement.[87] It was also interesting that it was the supplier deciding when to involve the customer and not *vice versa*. This indicated that it is not always the case of the customer deciding when to involve its suppliers, but at least in some circumstances a more interactive process.

There was no indication that network effects in any way influenced the timing of involvement of suppliers. The general policy was that if it had been decided to involve a particular party then the party should be involved at the appropriate time, independently of any conflicting network relationships, or their consequences.

6.2.3. Mobilising

The focal company TVR appeared to be the only actor of those interviewed with problems of mobilising suppliers to deliver parts to its engine development project. The TVR respondent believed that the lack of size and thus purchasing volume and value elucidated its mobilisation problems. This was despite the good reputation of the focal company:

> *Some people are very keen to deal with us because they want to include us in their portfolio and be able to say: "We make this part for TVR or whatever". We are seen as a high profile product. Particularly some new suppliers just so they can say they deal with us and they will be very helpful - particularly at the beginning.* (TVR Chief Engine Designer)

Nevertheless, TVR often found difficulty in mobilising larger suppliers. This seemed to be a result of the small proportion of the business of large suppliers for which TVR accounted; in those terms this problem could therefore be attributed to a network effect.

[87] The respondent from 'Pharma' specified development times as 'at least 8 - 10 years' and costs as 'at least 120 million UK pounds'.

In another two cases, the car development project and the viral-drug development project, the incremental and historical nature of the relationships seemed to provide an impetus for the suppliers of the focal companies. The two large focal companies seemed to have few problems mobilising their suppliers; the value of their business may explain this pattern. It should be noted that the situation of the focal company 'Bio-Pharm' was different from the focal companies of the other cases, as its involvement was mainly 'downstream' or 'horizontal'. As a biotechnology-based pharmaceutical company, its supplier network was limited in size and significance compared with, for example, the supplier network of a car. Mobilising in the case of 'Bio-Pharm' was therefore a process of identifying the right individuals and convincing them of the potential of the technology being developed and thereby persuading them to invest in the future of the product and underlying technology.

6.2.4. Assigning Human Resources

There was evidence of some form of assigning of human resources in all the cases. For example, in the drug development project people had been extensively exchanged during validation. A commissioning team from the focal company, Pharma, spent one month with suppliers to ensure that their manufacturing processes were satisfactory, effectively working as part of the supplier's company. Similarly, suppliers would sometimes transfer a whole team to work within Pharma. This was the situation when suppliers had developed a novel innovation and thus need to ensure apt integration. Hence, 'assigning' human resources was by no means a one-way process, but an interactive process of mutual exchange of both individuals and in some cases whole teams.

Assigning of human resources seemed to be less extensive in the cases of the engine development project involving TVR and the viral-drug development involving 'Bio-Pharm'. One explanatory factor may be that these were both relatively small companies whose resources could not extend to such resource demanding initiatives. Indeed, the three large focal companies were involved in extensive arrangement of short-term exchange of employees, such as resident engineers, with suppliers.

There did not appear to be significant network effects on the activity of assigning human resources. All the focal companies interviewed were concerned about confidentiality risks, however they seemed to manage this by high levels of trust and confidentiality agreements.

6.2.5. Informing

The risk of loss of knowledge seemed to be a concern in all the cases. Nevertheless, the view was often expressed that limited leakage of information and knowledge occurred. Even in the case of the drug development project the industry was seen as a closely-knit community, so that if a company or individual were to leak knowledge they would have no future in the industry. However, one respondent perceptively described the paradoxical nature of this problem:

> *If we are working with people at the forefront of what is going on people tend to get to know about it. But you are also using the fact that they have knowledge because they have interacted with other people.* (Bio-Pharm Business Development Manager)

The companies had different means of handling the inevitable risks, but efforts to segment knowledge and inform people on a 'need to know basis' seemed to be the common way in which these companies coped with the risk:

> *We have a corporate partnership with [two large pharmaceutical companies], but we keep them separate and we have separate confidentiality agreements. You try to build up different brick walls. It is a small world. Also sometimes people change jobs.* (Bio-Pharm Business Development Manager)

The respondent in the car development project explained how suppliers were expected to be aware of the risks involved in new vehicle projects and provided guidelines on security videos and conferences as to what could and could not be divulged, for example, that parts or information on notice boards must not be exposed. Nevertheless, there was also evidence that the amount of information would be restricted if there were risks that valuable knowledge would be lost to third parties through common relationships. The TVR respondent expressed it this way:

> *One example is some new material on crankshafts, where because we are in this unique situation that we don't need very many we can't afford high cost tooling. So we're*

always looking for ways to make better products with lower cost tooling. So we have looked at doing a different type of castings, which really started in America on high volume stuff. They developed a newer type of cast iron with better properties. So we started working on that, but no one else in the UK was using it at the time. We started to work with a company that was doing the heat treatment process for us which is the key to the technology. They were very interested. So this was a bit of a partnership were both parties gained. They gave us a lot of help and experimented a lot with the heat treatment. They gained from the knowledge. At the end it went a little bit wrong because [a large vehicle manufacturer] became involved in wanting to develop this for their crankshafts and they knew this company was doing it in the UK. A conflict of interest developed because we didn't want to divulge too much information that we had learned from the mechanical design to make the casting heat treatment properly. The heat treatment company obviously wanted to work for them and wanted to help them as much as possible. So we had gone along really well, but came to this point where another manufacturer became involved and we started to become a bit reserved as to what we told them, because we knew they were dealing with a competitor of ours. From previous dealings with [the large vehicle manufacturer] we knew they had copied things from us after having come round our factory. (TVR Chief Engine Designer)

Thus, the companies interviewed seemed sufficiently confident that, if managed properly, confidentiality would be respected. In those cases where it could not be avoided it was an inevitable risk with which companies simply had to cope.

6.2.6. Synchronising

In all cases except the engine development project the focal companies had made substantial efforts to synchronise systems, such as EDI or e-mail, and milestones and timetables, in addition to technical and quality standards such as ISO9000. The focal company in the engine development project, TVR, recognised that this was probably a limitation due to TVR being permanently under-staffed. Thus, its lack of management resource may explain its reliance on suppliers to synchronise amongst themselves.

Systems were synchronised in the case of the drug development project. Pharma did not impose these, but suppliers increasingly adopted similar standards and technologies. A network effect in this case was that actors supplying a range of customers could end up with different systems. Pharma coped with that problem by encouraging suppliers to synchronise principles rather than mechanisms or systems. In the case of the car development project a synchronisation problem caused by network inter-connections related to different EDI systems:

> *EDI is an example of that because several suppliers have different standards of communicating to different automotive partners, so the more multi-national suppliers may have more than one type of EDI. They have to make sure their standards conform to ours.* (Vehicle Manufacturer Logistics Manager)

In the majority of the cases, however, there seemed to be no other significant network effects on synchronising.

6.2.7. Co-ordinating

The focal companies across the five cases made various efforts to try to co-ordinate their suppliers, but some largely left this to their first tier suppliers.

In the case of the engine development project TVR did not attempt to actively engage in network co-ordination. The rationale provided was that "*These people tend to know each other better than we do*" (Chief Engine Designer). TVR's lack of influence and resource also elucidated this approach.

Other respondents, however, and most evidently the respondent representing the vehicle manufacturer in the car development project, tried to co-ordinate suppliers more formally through mechanisms such as supplier conferences and workshops. In this case the core product development team, which included not only staff from different functions within the focal company but also staff from suppliers and main dealerships, served as the co-ordination point. In addition, some suppliers were actively encouraged to unite when involved in the same mechanisms or systems. However, in the case of modular suppliers it was the module supplier's responsibility to control and co-ordinate sub-suppliers thus indicated a dissemination strategy. There was also evidence of the vehicle manufacturer specifying, for example, seat plane suppliers to the modular seat supplier, hence indicating an intervention strategy. The evidence of such co-ordination across the five projects, however, was only beginning to form.

6.3. Discussion and Conclusions

In the final section of this chapter, the results of the findings are addressed in terms of the three objectives that were outlined in the introduction to the chapter. These were: 1) to explore the usefulness of the initial set of collaboration activities emerging from the research; 2) to explore how the management of the activities may be constrained and/or enabled by the surrounding network; 3) to explore possible differences in the management of collaboration activities and network effects across different circumstances. These objectives are considered in the subsequent three sections, followed by a section on overall methodological lessons from the exploratory mini-survey.

6.3.1. The Usefulness of the Initial Set of Collaboration Activities

The 'cases' demonstrated that although the concepts of identifying/selecting, timing, mobilising, synchronising, assigning human resources, and co-ordinating, were useful in describing and analysing collaborative innovation in networks, not all were equally refined. Therefore, some adjustment was required.

The exploratory mini-survey revealed different aspects of each collaboration activity and network effects and thus helped to develop ways of operationalising the activities for the case studies. However, it became clear that the nature of some of the activities, most notably identifying/selecting, informing, and 'assigning human resources', was largely unidirectional, as the perspective in these activities was predominantly on the actions of one actor, the focal firm, at the expense of the actions – and re-actions – of other network actors. Hence, the perspective was not entirely interactive.

'Partner selection' and 'prioritising' were key activities in the research by Wynstra (1998) and Håkansson and Eriksson (1993), which had inspired the construction of 'identifying/selecting' as a key collaboration activity. However, the exploratory interviews indicated that neither was a satisfactory construct. The exploratory interviews illustrated that actors were not simply identifying and selecting other actors in a rational fashion; in some cases they were at least as much subjected to being identified and selected. In fact, several respondents used the expression 'coming together'; thus the exploratory mini-survey led us to replace the process of 'identifying/selecting' with 'uniting'. The two activities of 'informing', one of the core constructs in the research by Wynstra (1998) and Håkansson and Eriksson (1993), and 'assigning human resources', developed on the basis of e.g. Womack *et al* (1990), had to be substituted with, respectively, communicating and exchanging human resources for the same reason.

Furthermore, it seemed important to distinguish pure information exchange (or communicating) from knowledge exchange. Information can be defined as "easily codifiable knowledge that can be transferred without loss of integrity once the syntactical rules required for deciphering it are known. Information includes facts, axiomatic, propositions, and symbols" (Dyer and Nobeoka, 2000, p. 348). In comparison, know-how, and knowledge, is often tacit, 'sticky', complex, and difficult to codify (Nelson and Winter, 1982). Recent innovation research has highlighted the importance of knowledge management and exchange of different forms of knowledge (e.g. Nonaka and Takeuchi, 1995; Leonard-Barton, 1995). The findings gained as part of 'informing' did not fully capture the wider spectrum of knowledge in addition to information, including the tacit and complex dimensions. Therefore, it was decided to divide information and knowledge exchange into two separate activities.

The activity of 'co-ordinating' appeared to constitute an important part of managing collaborative innovation in networks. However, there seemed to be co-ordination elements within several activities. Inclusion as a separate activity therefore implied an overlap in the conceptual structure. So following the exploratory mini-survey it was decided to remove it from the set of activities as it was seen as an element of all activities. Instead it was included in the conceptual framework as one form of network effect (see Chapter Four). As a result, the lessons concerning the set of collaboration activities led to a reformulation of the set of activities as shown in Table 16:

Table 16. Revised Set of Collaboration Activities

Activity	Definition
Uniting	The process of identifying actors, including selection criteria – or being identified/selected
Mobilising	The process of motivating actors to commit to project, including establishing ground rules and objectives and arranging sharing of risks and benefits
Synchronising	The process of mutually adapting activities and resources, including development procedures; aligning objectives and technology roadmaps
Communicating	The process of exchanging e.g. design ideas, concepts, policies, procedures and performance information
Knowledge exchange	Exchanging e.g. technical knowledge, and end customer demand knowledge
Exchanging Human Resources	The process of allocating (on long-term mutual basis) staff to development projects e.g. resident design engineers
Timing	The process of deciding the moment or stage of involving actors in the project

In summary, the initial activities were useful in describing different ways in which focal companies involved a variety of different actors in different forms of innovation projects. However, three of the activities within the initial set of activities were primarily unidirectional. Hence, this led to the development of a revised set of collaboration activities that was more interactive than the initial set of activities. Moreover, one activity, informing, was divided into two activities: communicating and knowledge exchange; another activity, co-ordinating, was removed from the set of activities and was incorporated into the conceptual structure as part of the 'positive network effects'. Further conceptualisation (see Chapter Four) led the researcher to believe that the revised set of activities would be useful in analysing collaborative innovation management in networks.

6.3.2. Constraining and Enabling Network Effects on Collaboration Activities

The cases unveiled a number of constraining and enabling network effects across the initial set of activities. For example, in the case of the engine development project, TVR viewed the risk of loss of knowledge to competitors via common suppliers as a real problem. The respondent specified that as a direct consequence of fears of such risks TVR avoided dealing with large suppliers because they often worked for its competitors. Several examples of how third party relationships had constrained technical development were highlighted. At the same time the cases revealed the criticality of network connections in technological innovation. In fact, the cases illustrated the dialectic nature of collaboration. On the one hand focal companies such as TVR had serious concerns about dealings with companies that supplied competitors and could be expected to transfer knowledge and technologies to competitors. On the other hand several focal companies, including TVR and Bio-Pharm, appreciated that their collaboration partners possessed their knowledge and expertise exactly *because* they supplied other companies.

The cases demonstrated that although 'third party relationships' did capture some network effects, it only presented a partial element of network effects on collaboration activities. For example, it did not reveal much evidence of different forms of network dependency. Likewise, it did not produce many examples of network co-ordination. The engine development project was not a case of strategic network co-ordination or 'management'. There was extensive networking within dyadic relationships and within the wider network. Whereas this might have been expected, the relative lack of examples of network co-ordination in the cases of larger focal (or non-focal) companies was disappointing. The lack of such examples could be because these effects were not important, however, a more plausible explanation was that not all network effects had been captured through the concept of third party relationships, indeed most examples were captured as part of discussions of 'co-ordinating'. This implied that different ways of capturing different forms of network effect had to be considered for the in-depth case studies (see Chapter Four).

6.3.3. Different Patterns Across Different Circumstances

The final objective of the exploratory mini-survey was to explore possible differences in the management of collaboration activities and network effects across different circumstances.[88]

Comparing the automotive and pharmaceutical cases, the idiosyncrasies of the pharmaceutical industry in many ways stood out. Supplier involvement in product development appeared to be less of an issue in the biotechnology case as there were hardly any suppliers of ingredients involved due to the R&D nature of the focal

[88] Looking across the five projects, it was clear that the focus of the discussions, and therefore data consistency, varied significantly. This was due to the exploratory nature of the study, which meant that premature operationalisation was not desirable.

company. Rather, a number of 'horizontal' relationships appeared to be significant, such as relationships with academics and licensing and alliance partners. Investigation of the literature subsequent to analysis of the exploratory survey highlighted that similar observations had been made elsewhere (Tidd and Trewhella, 1997; Tidd *et al*, 1997). From an analysis point of view, different forms of horizontal relationship may be problematic to compare with relationships that can be classified as customer-supplier relationships. Indeed, Tidd *et al* (1997, p. 63) warn against generalising conclusions across the automotive and pharmaceutical/biotechnology industries, as the challenges faced by companies within these industries are profoundly different. The role of regulatory bodies also seemed to be particularly important in the pharmaceutical and biotechnology cases. Whereas regulation was clearly important in the automotive industry (it was after all a trigger of the exhaust system development) it appeared to constrain development and management processes and systems in a much more fundamental way in the pharmaceutical and biotechnology industry.[89] This included the role of testing, which is important in the automotive industry, but is arguably more time consuming and regulated in the pharmaceutical industry. Conversely, the strong role of regulation might also provide an advantage in the extent to which sensitive knowledge can be protected as it provides the basis for the relative strength of the intellectual property regime in the biotechnology and pharmaceutical industries (Teece, 1986; 1998). Whereas the differences between the two industries therefore provided useful contrasts, comparisons of the patterns of collaboration may be problematic. For these reasons, it was decided that the pharmaceutical and biotechnology industry should not be included as part of the in-depth case studies, but substituted with an industry that would be more easily comparable with the automotive industry: telecommunications.

The survey also indicated that contextual factors, such as company size might affect patterns of collaboration and network effects. It appeared from the findings that the size of the focal companies and consequently their relative lack of resources, had a bearing on the extent to which they were able to engage in network co-ordination; their main approach seemed to be informal networking. This is consistent with prior research on the impact of size as a contextual variable, which has shown that small firms differ in terms of their access to resources and so need to develop more linkages and *network* more extensively (e.g. Rothwell and Zegveld, 1982). The relative lack of power and

[89] For a discussion of the relative importance of regulation across a variety of industries see the MIT

influence of small firms over other network actors also seemed to be a key contextual factor, as did their vertical 'value chain' or 'supply chain' position. The majority of existing research has examined collaborative innovation from the perspective of powerful assemblers rather than component suppliers. Existing research shows that large powerful assemblers, such as vehicle manufacturers (e.g. Womack *et al*, 1990), may be able to exert a great deal of power and control over their supplier networks. Less research has examined the problems of managing collaborative innovation projects from the perspective of suppliers. This was therefore seen as an avenue of future research to be pursued in this study.

6.3.4. Methodological Lessons

The final part of this section discusses two methodological lessons that were gained from the exploratory mini-survey.

Unit of analysis: product versus product technology

All the five projects studied as part of the exploratory mini-survey included discussions of products, and product and process technologies. The literature review had attempted to clarify the meaning of these concepts and identified that the distinction between the concepts is often blurred. It is particularly problematic as distinctions often depend on the perspective, as one actor's 'product' can constitute another's bought-in technology. However, the main unit of analysis in three of the projects investigated in the mini-survey, concerned 'finally assembled products' rather than product technologies. In the case of the exhaust development project the unit of analysis concerned a vehicle product technology; in the case of the viral drug development the development of a new product technology and its application into a new product (and potentially several new products) was the main focus. The result of this diversity in units of analysis made comparisons problematic; it was to some extent an outcome of the chosen focal companies within each case but also a result of the choice of unit of analysis. More clarity as to the problem of unit of analysis would be required for the in-depth case studies.

survey (1995) on the impact of innovation (Http://web.mit.edu/newsoffice).

Choice of respondent

The exploratory mini-survey experimented with interviewing people from a variety of functions within focal companies, representing engineering, purchasing, supplier development, logistics, and business development. In addition to experimenting with the type of respondents that would be relevant to include in the in-depth case studies, there were two main reasons that had led to such a spread: 1) a pragmatic consequence of using existing contacts of the researcher; 2) it is increasingly problematic to identify potential respondents based on stereotypical functional roles, such as engineering, marketing or purchasing, because organisations no longer conform to traditional functional structures. Despite these reasons, the widely different roles and responsibilities of the respondents resulted in somewhat biased findings. It is likely that the risks of bias were significant as a result of this diversity. From this experience it was concluded that respondents representing the commercial functions of purchasing and marketing, in addition to engineering/technical would be most centrally positioned and thus likely to fully appreciate and comprehend the subject matter, more so than, for example, logistics or supplier development managers (although the case studies would seek to interview a wide variety of respondents to provide a complementary picture of technological innovation projects).

CHAPTER SEVEN: FINDINGS FROM FOUR IN-DEPTH CASE STUDIES

7.0. Introduction

Chapter Seven reports on the findings from the four in-depth case studies that form the core of the empirical study. Each case is discussed in sequence, beginning with an outline of the specific context of the case; identifying the main features of the focal company, the innovation project (the main unit of analysis), and the structure of the network. Each case then continues with findings on network effects on each collaboration activity, divided into enabling and constraining effects. A summary of the main network effects on collaboration activities is then provided, followed by an assessment of the performance of each collaboration activity, including the perceived extent of collaboration shown in each activity. Chapter Eight focuses subsequently on cross-case analysis and discussions.

7.1. Fuel Tank Project

7.1.1. Context[90]

The fuel tank development project concerns the second product application of a new technology. The focal actor in this case concerns a company, here referred to as 'EuroPart', which is a relatively recent joint venture between a UK company and another European company. The actual JV is a relatively small organisation, however, both JV partners are very large organisations that are primarily automotive component suppliers.

EuroPart has a small product portfolio, concentrating on the manufacture of fuel tanks for vehicle manufacturers. It is based on a new and unique technology which has only been applied in a few products to date; it had some level of input in the design and development of product applications of the technology, but the JV was not directly involved in the development of the actual technology; this was mainly the contribution of one of the JV partners.

[90] Some details of the case studies have been concealed for confidentiality reasons, including the identities of the companies, technologies and products concerned.

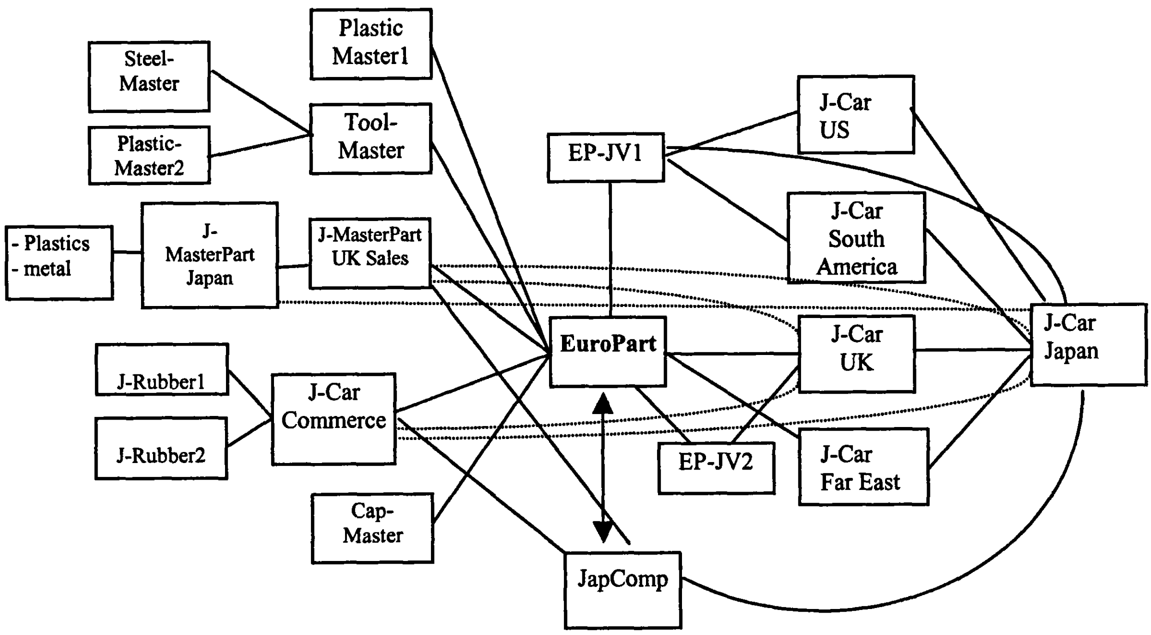
The innovation project was primarily chosen because it has been recently completed, entering production ramp-up in the beginning of 2001. EuroPart regards the underlying technology as very innovative, although a few competitors have now developed similar technologies. The actual product application is not viewed as particularly innovative, although some of the processes used, e.g. unique testing technology, were first developed for this application.

The structure of the network is illustrated in Figure 21. Some of the components are included, although the actual names are disguised to retain confidentiality. EuroPart is placed in the middle of the drawing as the focal company. EP-JV1 refers to the European JV partner, whereas EP-JV2 refers to the UK JV partner. It is also a noteworthy feature of this case that there is only one customer: 'J-Car' which is a Japanese vehicle manufacturer, with headquarters and R&D centre in Japan, and a UK sales office. JapComp is the dual source used by J-Car and thus the competitor of EuroPart.[91] On the supplier side the network map includes a small set of suppliers that appeared to be important in this project. PlasticMaster is a key plastics supplier. ToolMaster is a small tooling supplier, which is a specialist in blow- and injection moulding and high-pressure die-casting. It produces and supplies the tools, although not the major blow-moulding tools which are internally supplied within the JV, and supplies injection-moulded parts to EuroPart. J-Car Commerce is fully owned by J-Car. Its role is purely to source so-called 'child parts', or sub-components, into European tier-one suppliers for J-Car. J-MasterPart UK Sales is the UK sales office for a major Japanese parts supplier (J-MasterPart Japan) with strong links to several Japanese vehicle assemblers. The main types of components are included in the drawing.

The network map highlights some of the inter-connections between key actors; the effects of these will be discussed in more depth later.

[91] It should be stressed that only the apparently most important actors are included in this map: the multitude of subsidiaries and so on of each individual actor is only included here in its most basic form.

Figure 21. Fuel Tank Development Project: Network Map



- Full lines: Relationships involving physical exchanges/supply
- Dotted lines: Commercial and technical exchanges, including design changes, volume schedule changes, phase out/in timing information.
- Doubled headed arrow: Perceived competitive relationship (by EuroPart)

The activities that took place during the course of the project as part of the management of the relationships shown in Figure 21 are to be discussed in the following section.

7.1.2. Collaboration Activities

Uniting

This activity referred to the process by which EuroPart identified and selected the customer and the key suppliers in the project (or *was* identified and selected hence the term 'uniting'). The findings indicated that EuroPart was chosen by the customer, J-Car UK, having successfully tendered for the business in competition with three or four suppliers. The process was formalised by the customer, using a performance measurement system. It could thus be described as an interactive process, with the customer actively managing a process of supplier selection and EuroPart, equally actively, seeking the business. This picture appeared to be consistent across the relationships investigated.

Network as enabler of uniting:
The main theme in this case concerned the issue of network intervention by means of sub-supplier nomination, in terms of J-Car specifying second and third tier suppliers for key components. One of EuroPart's suppliers, J-Car Commerce, explained the rationale:

> *The reason that most of these child parts come from Japan is Japan as [J-Car's] mother country, they will not basically for want of a better word trust anyone else to make [the key part] So although some of the Japan suppliers that I source parts from have European operations, [J-Car} R&D will not authorise the localisation of that part at present.*

J-Car Commerce itself, however, was not one of the specified suppliers, but acted as a conduit to two Japanese specified suppliers:

> *[EuroPart] would have probably said 'Well, we have no relationship with Japan. We're not a Japanese transplant. How can we source these' and at which point J-Car would have said 'Ah! We have a trading company. You don't have to use them but you may be able to, they should be able to give you the cheapest possible cost and they also will assist you because breaking the language barrier, communicating with the manufacturers, they will not have any design responsibility but they will be able to help you out by passing through any requests you have to Japan.' So it's a sort of* fait accompli *in a way.*

The rationale for the strategy of intervention in choices of key suppliers, was captured by J-Car UK:

> *[It is a] safe pair of hands really. They're known to, because they've got the advantage of being with the, like I say the Japanese team in Japan, very close links, they'll feel a lot happier giving them business as opposed to some company maybe in the UK. It might be just as good to be able to make the parts just as well but there's no history, no links, no close contact.*

In other words, network intervention in uniting was exercised through sub-supplier specification or nomination and was used as a means to reduce risk in crucial supplier relationships. Hence, the trust that had been developed over time in the culturally similar relationships provided a means to reduce the risk inherent in any innovation. Moreover, the network acted as an enabler in the case of J-Car Commerce acting as a sourcing, and hence conduit or access, function. This appeared to be important in this case not least due to the cultural and geographical distance between EuroPart and its sub-suppliers.

Network as constraint of uniting:
Whereas sourcing through J-Car Commerce was supposed to be an advantage for EuroPart, interviews with respondents within EuroPart as well as suppliers revealed that the consequence of this system was that they had little control over the critical decision concerning their choice of suppliers. It resulted in the company being 'landed' with relationships, which were not of their own choice. Thus, the company had no ownership of the supplier network which meant, for example, that EuroPart's opportunities for making a profit, were limited in its core relationships:

> *"If you're given nominated suppliers the customer already knows the price, so you can't put any profit on there. In other ways it does benefit us because we can turn around and say 'You nominated them."* (EuroPart)

Respondents were also asked whether they had avoided any suppliers. The analysis shows some discrepancy regarding whether EuroPart deliberately avoided any suppliers or customers; one respondent reported that a problematic supplier had been avoided, another that no particular suppliers had been avoided. However J-Car-Commerce admitted:

> *I would deliberately have avoided [RubberMaster1] if I had had any choice at all. They are a pain in the neck supplier for me. But basically I have no choice because J-Car have nominated [them] to make that part, [EuroPart] need that part in their [fuel tank].*

The practice of sub-supplier nomination exemplifies one type of network influence in this activity: intervention in the supply base. From EuroPart's perspective this was largely seen as a damaging exercise as it reduced its level of influence on a critical managerial decision for managing innovation in networks: the choice of key supplier relationships. Therefore, it constituted an administrative or logistical dependency.

Path dependency also seemed to be significant in this case. This was not only in terms of the importance of primarily ending up with suppliers which the company had worked with in previous projects, but also in terms of the importance of suppliers being able to show a track record; a portfolio of relationships to their benefit:

> *"By the nature of the components we supply, we're not looking for suppliers who will only supply parts to [EuroPart]. We'll be looking at their proven track record."* (EuroPart)

However, as the quote implied this functioned more as an enabler than as a constraint, providing an important term of reference. It indicated that EuroPart deliberately wished to involve suppliers which had other customer relationships, perceiving this as a definite strength rather than a problem. This was a general characteristic of the culture of the whole network as the same attitude was expressed, for example, by J-Car UK:

> *Basically if they make mistakes with them we can learn from those mistakes, [EuroPart] will learn from those mistakes. It's always good if they are doing that and also you get some kind of understanding whether they're a good supplier because they've got other customers...... We can learn from their mistakes and also we can share facilities. So in this case you can't necessarily share everything but [the key machine tool] for instance we share with [another vehicle assembler].*

Hence, there was evidence of administrative or logistical dependency on the process of uniting, significantly constraining the process of uniting in terms of the lack of freedom of supplier selection. This was a negative consequence of the intervention strategy applied by J-Car, EuroPart's large customer in this project. There were also elements of path dependency, although this had a positive enabling effect on uniting rather than a negative effect.

Timing

This activity referred to the stage at which actors become involved in the project. Early supplier involvement has been proposed as a core concept in improving, for example manufacturability, however, as this case showed this did not necessarily mean that it always happens. In fact, one of EuroPart's suppliers, ToolMaster, explained how late involvement of tooling suppliers was a common problem in the industry:

> *[When we're involved too late] it gets to the point where their delivery or supply parts for [the vehicle assembler] or whoever that date is very much in stone and we get*

> *involved so close to that date that we can't make changes so it has to go with the design.... We've done so many tools here that we know are wrong and we've told them they're wrong with that spec. but they mould it and then modify later on, with costs.*

Several respondents suggested EuroPart was involved at the design/concept stage prior to nomination and that its key suppliers became involved immediately afterwards or in parallel with EuroPart. On the surface, the indication from the internal EuroPart interviews was that it was a case of early supplier involvement throughout all key relationships. However, other respondents, notably J-Car UK and J-MasterPart, revealed that the design was more or less completed by the time EuroPart joined the project. The design sprang from a similar development already having been completed in Japan. The EuroPart Purchasing Manager considered what he believed to be the late involvement of his company to be a source of many problems during the project. However, as highlighted in the following section, several respondents were still of the view that timing of supplier involvement overall had not been a weak point in this project.

Network as enabler of timing:
EuroPart was keen to involve its suppliers as soon as possible in the process. This was not least an outcome of previous experience, which in this case evidently functioned as an enabler rather than a constraint:

> *I would say actually for [EuroPart], if anything, we probably got involved earlier than we would have done because from experience from [the first product application] we knew how long the lead time was. We knew, not how difficult the Japanese manufacturers could be but, how inflexible they could be and it was a case that if between us and [EuroPart] we started rattling cages early, we knew we would get the rewards later on.* (J-Car Commerce)

This quote indicated the positive effect of shared experience, and thereby path dependency, on the timing decision. It was clear, however, from all the internal interviews with EuroPart that although it was eager that its suppliers be involved as early as possible in the project, it did not seek to influence at what stage its suppliers were to involve their suppliers, regarding it as a decision best left in their hands. Although this could indicate an implicit strategy of dissemination there was no evidence of any explicit attempts to disseminate or delegate decisions regarding the timing of sub-suppliers. EuroPart also believed that its performance monitoring process would have highlighted any problems of indirect suppliers not being involved on time. This was the same picture across all supplier interviews, albeit the interview with J-Car UK revealed that it did make sure that suppliers further down the 'supply chain' were involved and assessed.

Thus, there was evidence of a positive path dependency effect on the timing of supplier involvement, although there were no recorded attempts by EuroPart to influence the timing of sub-suppliers.

Network as constraint of timing:
A possible restricting effect of the network on timing might have been that companies would deliberately seek to delay the involvement of certain suppliers, for instance, because of confidentiality concerns. However, all of the internal and external respondents were of the view that once it had been agreed and approved that suppliers were to be involved there was no reason not to involve them as soon as was possible and feasible. The general consensus was that if there had been any concerns whether a supplier was trustworthy, it would not have been involved in the first place.

Therefore, there were no apparent negative network effects on the process of timing.

Mobilising
This activity focused on measures used to motivate and establish ground rules within relationships. It included issues related to the sharing of risks and benefits and the formulation of project objectives.

The risks in relation to costs incurred in connection with development were generally incorporated into piece cost, leaving the eventual costs to be covered by J-Car, although EuroPart had to finance some work itself e.g. testing. Furthermore, EuroPart financed tooling costs in some relationships. EuroPart initially developed a project plan in response to J-Car's requirements during quotation. However, several respondents were of the view that there was some uncertainty regarding ground rules, as explained in the following sections.

Network as enabler of mobilising:
The enabling effects of the network on mobilising appeared to be limited. EuroPart's relationships with, for example, its American and Continental European arms had had a

useful impact on its dedication to the project in the UK, enabling it to benefit from the experience and expertise available through those relationships. This was seen by J-Car UK as a particularly important factor in EuroPart's ability to cope with the project.

Regarding active network co-ordination for mobilisation purposes, the general consensus within EuroPart was that the company hardly had the resources to motivate its direct suppliers and thus preferred to concentrate its efforts on those rather than attempting to mobilising beyond direct relationships. There were no explicit accounts of use of a dissemination strategy.

Network as constraint of mobilising:
As a whole, EuroPart did not believe it had any significant problems mobilising suppliers due to the volume, value and prestige of the business. A problem that perplexed EuroPart, however, was that its single most important supplier, J-MasterPart, did not regard EuroPart as its customer; it viewed J-Car as its customer despite the fact that it supplied through EuroPart (see Figure 21). EuroPart considered this de-motivating and frustrating:

> *"We had pre-meetings with [J-MasterPart] in the early days and they insisted on having those meetings in the presence of [J-Car] in the UK. They didn't recognise us as their customer, they recognise [J-Car] as their customer and treated us quite differently. So we had to use some kind of coercion with [J-Car's] agreement to get them into line. They are very reluctant to deal with us direct, they want to go through [J-Car's UK Office] rather than talk to us direct."* (EuroPart)

This quote illustrated not only the damaging effect of the relative lack of recognition on motivation but also on communication (as discussed later). Furthermore, it reflected a rather tense atmosphere within the EuroPart-J-MasterPart relationship. The problem seemed to be caused by the different perceptions of the roles and responsibilities of different actors within the network and hence effectively the consequence of sub-supplier nomination. Therefore, the intervention strategy applied by J-Car again appeared to have a negative effect. Conversely, this exemplified a form of administrative or logistical dependency and it showed the close link between dependency and power in the network. The problem even led to suppliers ignoring EuroPart's project manufacturing planning:

> *"[J-Car] will obviously issue a master timing plan, which we will then break down into our project timing plan which, for simplicity, will suggest if [J-Car] wants parts in June, we'll try to get delivery for those parts for May, suppliers will then deliver those parts for April. But what tends to happen is that our timing planning does not get a lot priority in the supplier base, they'll concentrate on delivering parts for June for [J-Car]. They tend to forget our business. That's a common problem."* (EuroPart)

It was not only EuroPart struggling with certain suppliers that did not recognise it as an important customer. The interview with J-Car Commerce confirmed that the lack of "clout", or power, of European suppliers in Japan meant that EuroPart would always be regarded as a secondary business. J-Car UK, the arm of the Japanese vehicle assembler which was the originator of the problem, having decided to specify key suppliers, was somewhat puzzled by this situation where J-MasterPart refused to recognise EuroPart as a customer. The J-Car respondent saw this as a highly unusual situation. J-MasterPart was aware that a problem existed and had therefore taken the initiative to hold a three-way meeting (mentioned in the first quote by EuroPart above). In addition to J-MasterPart, this involved EuroPart and J-Car UK, seeking to resolve the problem, by clarifying roles, responsibilities and important ground rules. This effort apparently had a mediating outcome on the relationship between EuroPart and J-MasterPart, making it at least manageable, given the circumstances.

There were therefore indications that the administrative or logistical dependencies, which were manifested through J-Car's sub-supplier intervention, severely constrained mobilisation. The case also showed how the issue of dependency was closely linked with the different degrees of power of different actors, and hence their relative recognition within the network; it seemed to constitute a source of much conflict and friction.

Communicating

Communication between EuroPart and its customer concerned exchange of design ideas and drawings, which on the development side mainly took place between EP-JV1 and J-Car Japan, and on the manufacturing side between EuroPart and J-Car UK. Most problems, as discussed in the following sections, were apparently related to the latter. In either case J-Car was perceived to be the focal point of communication. Communication also involved the day-to-day communication of more supply-related information, for example, environmental, health, and safety policies and procedures, and supply or delivery performance information; feed-back during development was more informal and irregular than during production, being a case of mutual monitoring through email messages.

Network as enabler of communicating:
The network seemed to enable communication by providing informal access to information on competitors:

> *"People are quite open, it happens, it's quite an incestuous industry, so you know who deals with who...... we all know each other basically. I bump into our competitors representatives at our customers' place all the time."* (EuroPart)

J-Car Commerce also resorted to this form of 'networking' when on EuroPart's behalf it attempted to gain some 'semi-internal' information from J-Car, for example, concerning launch delays, a source of confusion within EuroPart. This type of activity thus seemed to exemplify the use of the network to access and thereby facilitate communication.

There was limited active network co-ordination on EuroPart's behalf. Communication beyond the second tier was regarded as the responsibility of the second tier. EuroPart would only intervene by directly communicating with, for example, third tier suppliers if there were a specific concern, such as wanting to ensure that suppliers were on target and able to meet project deadlines.

Network as constraint of communicating
The central theme of EuroPart's communication with key suppliers and the customer revolved around the effects of the complexity of the network. J-Car had a close direct relationship in the UK and Japan with EuroPart's most important supplier, which subsequently did not recognise EuroPart as its customer. This meant that EuroPart was often circumvented in the communication between these two companies. Moreover, in some ways J-MasterPart's relationship with J-Car appeared to be closer than the relationship between J-Car's headquarters and its UK office. J-MasterPart, in this case being second tier, would often receive information before EuroPart as well as J-Car's UK office (see Figure 21). The following quote illustrates this complexity:

> *"Japan has spoken to the supplier, especially in the case of [J-MasterPart]. So I'm requesting [J-MasterPart] to supply what I think is the latest level because [J-Car] has sent me this drawing, and they say 'Oh no, you don't want that, there's been design change since, you want this level'. So [J-Car] is not telling me what I should buy."* (EuroPart)

EuroPart was thus entrapped in this convoluted arrangement, which provides a salient illustration of not only administrative or logistical dependency but also technological dependency; its communication suffered from the attempts by J-Car to intervene in the network. J-Car UK did not, however, deliberately wish to intervene in the communication. However, the agreements, which had been made between its Japanese headquarters and two key second tier suppliers, nevertheless had an effect on how EuroPart was able to handle its communication. Apart from communication concerning design changes, as illustrated in the quote above, there would also be confusion regarding whose terms and conditions would apply. EuroPart, as a customer, expected its terms and conditions to apply with J-MasterPart, however, due to the unique relationship between the latter and J-Car this turned out to be problematic and ultimately J-MasterPart's terms and conditions were largely applied in this relationship. This was therefore a frustrating and restraining situation for EuroPart, which had lost the control of an important aspect of its business: the ability to set its own terms and conditions with a key supplier relationship. Once more, it reflected the tense atmosphere in the triadic relationship amongst EuroPart, J-Car and J-MasterPart.

Communication tended to be open within the main relationships except during quotation where information was "quite tight". In general, the relationships seemed to be permeated by a culture of openness in which actors were keen, or required, to exchange as much relevant information as possible for the smooth running of the project. This included cost and margin information, which was recognised by J-Car Commerce as putting EuroPart in a difficult position:

> *This is where it probably in a way works against [EuroPart] in that there's a very transparent pricing system. [J-Car UK] know exactly what price I'm selling it to [EuroPart] at. Whereas I guess if it's a normal supplier down the road, if [EuroPart] can get a very good price for it, then that's [EuroPart]'s good purchasing. For the parts that we supply it's the case that I tell them what the price is and I tell J-Car what the price is...*

This system of enforced cost transparency thus constrained EuroPart's ability to make a viable profit. The relationship between EuroPart and J-MasterPart was also restrained with regard to openness of communication. J-MasterPart admitted that design details related to its part and underlying technology were withheld from EuroPart because it was not seen as "part of the process" and because of fears that EuroPart might use the information to develop its own part. This indicated a fear of loss of knowledge through the network.

The generally high degree of communication appeared partially to be a result of the past experiences of the main actors. Previous experience had meant that EuroPart and J-Car Commerce knew that there was a need for as much information to be exchanged as possible:

> *From previous experience I gave them as much as I could get which meant getting as much from [EuroPart]... because for [the first product application] we had a lot of problems as I said. I wasn't prepared to assume that everyone knew about it this time and I think [EuroPart] were certainly the same as well. So although there's not masses of information available we got as much as we could to Japan.* (J-Car Commerce)

Path dependency, in terms of experience, thus seemed to have a predominantly positive effect on communication and hence, again, presented more of an enabler than a constraint on the fuel tank development process.

In summary, the process of communication was severely restricted by a variety of network properties, including administrative or logistical and technological dependencies, and (in a positive sense) path dependency. There were also indications of a network constraint in the form of fear of loss of knowledge from J-MasterPart to EuroPart, which impacted on the transparency of their communication.

Exchanging knowledge

This activity complemented communicating however it focused on 'technical engineering' knowledge. Thus, it also focused on the issues of technology application within the product development project. Other examples included knowledge of testing equipment and processes, and production processes.

Network as enabler of exchanging knowledge

The picture here appeared to be very similar to communication. EuroPart sometimes used network connections as points of access, particularly in the situations where it was struggling to obtain information itself. Curiously, J-MasterPart acted as EuroPart's access point in some cases as it was often better informed, for example, about design changes, than J-Car UK.

An interesting point was highlighted by J-Car UK concerning EuroPart's other customers. It was keen that EuroPart have other customers as it would enable EuroPart to learn from mistakes made with other customers and ultimately benefit J-Car. However, there was limited evidence of any active network co-ordination by any actor specifically aiming to facilitate learning and knowledge exchange, at least in the specific context of the project investigated.

Network as constraint of exchanging knowledge:

As in the case of communicating, the close relationship between J-MasterPart and J-Car had a negative effect on EuroPart ability to manage knowledge exchange. The Manufacturing Manager highlighted one example where EuroPart had become concerned about J-Car's 'over interest' in what it perceived to be its unique testing technology:

> *I'm aware with [J-Car] that at a point they were far over-interested in our technology and beyond product quality basis. They were very interested in all our operating parameters – the actual [core] technology. This was beyond was required.* (EuroPart)

J-Part Commerce further elucidated the consequence of this apparent "over-interest" in EuroPart's technology:

> *[J-Car] have expanded into [key parts] in Japan so they are now a supplier, I think maybe for [the car] in Japan.. [The key parts] were not a technology available in Japan very easily. [EuroPart].. I feel a bit sorry for them in that they were the experts in [the key part technology] and I would say in a way maybe they were used, information was shared and [key parts] are now common in Japan with [JapComp] and another UK customer is now taking over.*

These quotes indicated that knowledge was being withheld in certain relationships. Rather than openness it was a culture of knowledge exchange on a 'need to know' basis. Another example which supported this interpretation concerned the visibility of overall product architecture; suppliers tended to be informed purely of the part for which they were responsible. They did not have the visibility of the context in which their part was to fit. Some suppliers viewed this as a problem, however, most seemed to accept it as a necessity, as it provided a means to protecting knowledge dissipation.

There appeared to be limited impact of path dependency on knowledge exchange. The only indication was provided by J-Car UK, which pointed out that development experience was carried over from previous projects. Although this was evidently a matter of history impacting on the present i.e. past dependency, it is questionable whether it reflected path dependency. This is to be discussed in more detail later.

Exchanging human resources

This activity concerned the exchange of technical staff, most notably resident design engineers, to the project team; the focus was on long-term exchange, such as secondments, rather than mere human interaction such as meetings.

One example was that J-Car had asked EuroPart to allocate a resident design engineer to J-Car's development team in Japan. However, EuroPart decided not to offer this due to resource constraints and to maintain sufficient expertise in its continental European headquarter. EuroPart did, however have a sales and marketing office in Japan which liased closely with J-Car Japan and was responsible e.g. for producing the original drawings.

The interviews revealed limited knowledge of this activity because most of the relevant activity would have taken place in Japan e.g. possibly between J-Car Japan and J-MasterPart. Further interviews in Japan would therefore have been required to cast more light on this activity.

Synchronising

This activity concerned adaptations and alignments of systems and procedures. These largely revolved around the project, or "programme", plans that were being developed by the various actors involved.[92] Also this activity included alignment of technology developments or road maps, although there was limited evidence of this. Some degree of technology alignment, however, did take place at the level of the industry. Often vehicle manufacturers would respond to global requirements, for example, evolving legal and safety regulations, and hence ask suppliers how they were to manage these new requirements.

Normally, one would expect synchronisation to be a two-way process, however, here it was generally viewed as the supplier's job to synchronise with, or adapt to, customers rather than *vice versa*, albeit one respondent admitted that it was sometimes a matter of using whatever appeared to be the best system:

> *"We try to be pragmatic about it in so much that if they have got a system which works and which has all the elements which our system requires then we'd use their system, from a quality point of view, because if they know their system they are less likely to make mistakes. But if their system is completely non-capable of what we want, then we insist on them following certain patterns or rules. We have a document in place in that instant when companies are not capable of carrying it out [using their own system] and we tell them "Well, you have to follow this document". And spoon-feed them to a certain extent."* (EuroPart)

This quote indicated that whichever system ended up being applied depended on the relative usefulness of the systems. It also implied that it depended on the perceived capability level of the supplier. To put it more succinctly, it seemed to be influenced by the level of trust in the supplier's managerial systems capability.

Network as enabler of synchronising:
Suppliers generally seemed to have to synchronise with J-Car to align, for example, their milestones and procedures with those related to the vehicle development. As discussed in the previous section, one of EuroPart's problems was that some of its suppliers would synchronise with J-Car rather than EuroPart. This might therefore indicate that J-Car applied a dissemination strategy in its approach to synchronising, however, this was not explicitly verified by J-Car.

[92] Many respondents used the term 'programme' instead of 'project' even though they did not refer to long-term developments.

Network as constraint of synchronising:
Most synchronisations and adaptations were in place from previous projects, notably from the first technology application. Past experiences also allowed EuroPart to be alert to possible problems and pitfalls e.g. with particular suppliers. History thus again played a positive part in this activity rather than acting as a constraint.

Some respondents within EuroPart expressed concerns about aligning its technologies with suppliers as it was seen to be important to have a distinct offering to its customers. It was generally recognised, however, that a strategic decision for EuroPart concerned the problem of not being a real full-systems, or module, supplier, because of customer intervention in its choice of key collaboration partners. Therefore, although EuroPart effectively supplied a whole module it neither had full control over the design and production of the module, nor the commercial part of it:

> *What happens is that the customer will negotiate direct with the [key supplier] and they'll say to [EuroPart] 'You've got to use that [key component], and that's how much it's gonna cost you'. So all you do is that you get that [key component] and stick it in your [module]. The opportunity for making any money is very limited, other than a handling charge. (EuroPart)*

Some respondents recognised that it might be a viable strategy to develop some form of partnership with key component suppliers, thus maintaining control of the choice of collaboration partners. It was conceded, however, that vehicle manufacturers were unlikely to be pleased with such a decision, as it would imply that they would lose control of the network:

> *[The vehicle manufacturers] would be horrified, absolutely horrified. They would have no control over the costs. And I don't think it would ever work with [J-Car] because they're too close to the supplier base to allow that to happen; we'd never be close enough to the likes of [J-MasterPart] or whoever to make a system.* (EuroPart)

The challenge faced by EuroPart in seeking to become a full systems supplier was therefore very much a question of network control. If EuroPart gained control J-Car conversely would have to let go of some of its control of the network; a decision it seemed reluctant to accept.

The administrative or logistical and technological dependencies, which appeared to be outcomes of J-Car's supplier intervention strategy, thus also seemed to affect the process of synchronisation in terms of EuroPart's ability to control its own future technological direction.

7.1.3. Summary of Network Effects on Collaboration Activities

Table 17 summarises the main network effects on collaboration activities.

Table 17. Main Network Effects on Collaboration Activities

	Network as Constraint	Network as Enabler
Uniting	• Admin/logistical. dependency through J-Car intervention in sub-supplier nomination • Path dependency: FC suppliers need track record to become selected i.e. relationships with other customers	• One supplier acting as a sourcing/access function to Japanese 3rd tier suppliers • J-Car applies network intervention strategy through sub-supplier nomination
Timing	• No examples/cases	• Positive path dependency: previous experience had shown importance of early supplier involvement • No attempts by FC to influence timing of sub-suppliers
Mobilising	• Admin./logistical dependency: through J-Car intervention in sub-supplier nomination and management caused mobilisation problems	• Few significant effects: no attempts by FC to influence mobilisation of sub-suppliers • FC relationships with JV partners increased its dedication to project
Communicating	• Admin./logistical and technological dependency: FC circumvented in sub-supplier-J-Car communication re. design changes, terms & conditions, and cost/margin. • J-MasterPart withheld design information from FC to avoid loss of knowledge.	• Networking is way to access informal information e.g. re. launch delays • Positive path dependency: previous experience had shown importance of openness of communication. • J-Car applied network intervention strategy to communicate directly with sub-suppliers
Knowledge Exchange	• Similar to communicating • Examples of perceived loss of technology from FC to J-Car dual source	• Networking is way to access informal information e.g. re. design changes • Learning through (J-Car-FC-other customers) triad: positive path dependency
Exchanging Human Resources	• No apparent effects (limited respondent knowledge of activity)	• No apparent effects (limited respondent knowledge of activity)
Synchronising	• Admin./logistical and technological dependency: FC lacked control over its own module design and manufacturing due to J-Car intervention in choice of sub-supplier and technology	• Positive path dependency as previous experience enabled process

FC: EuroPart

7.1.4. Performance Assessment

The purpose of assessing the performance of the project was not so much to obtain hard objective performance measures, but rather an attempt to obtain an indication of the perceptions of the respondents. Nevertheless, as discussed in Chapter Five, the attempt to collect performance data from the pilot case proved to be problematic mainly due to respondents' lack of understanding of specific performance indicators, and the overall complexity of this part of the data collection. Consequently, attempts were made during data collection to improve the collection procedure and simplify some questions. A major improvement was to incorporate what was originally a separate structured questionnaire into the final part of the interviews. This enabled the interviewer to explain the meaning of questions that had been perceived as problematic to understand by early respondents. As a consequence the last two respondents were able to provide some performance information. Hence, the majority of data discussed below stems from the two final interviews.

Respondents were asked to indicate how the collaboration activities affected a) product development cost, b) product development time, c) the eventual cost of the product, and d) the eventual value of the product. Only the customer was able to provide such detailed information (second last interview), hence the reliability of the data is highly subjective.[93] The results are shown in Table 18.

Table 18. Overall Assessment of Respondent Perceptions of Collaboration Activity Performance

	Product development Cost			Product development Time			Eventual Product Cost			Eventual Product Value		
	+	+/-	-	+	+/-	-	+	+/-	-	+	+/-	-
Uniting	1			1				1			1	
Timing	1			1			1			1		
Mobilising	1			1				1			1	
Communicating	1			1			1				1	
Exchanging human resources[94]	1			1				1			1	
Synchronising	1			1			1			1		
Exchanging knowledge	1			1			1				1	

NB: Numbers refer to number of respondents having ticked positive, neutral or negative box.

Bearing the limitations in mind, it is interesting to note that the customer perception of the performance of the project was very positive, as the customer was very satisfied

[93] Although the customer may be seen as the most valid source of output performance information.

with both the process and the outcome of the project. All collaboration activities were perceived as having had either a positive or a neutral effect on product development cost and time, and eventual product cost and value. EuroPart's European JV partner confirmed that both target development cost and time had been met and supported this evaluation.[95] The customer respondent did recognise that there had been a number of problems during the project with regard to EuroPart struggling to obtain parts from Japan. However, he believed that these problems had been resolved through customer intervention. Given the plethora of problems experienced by EuroPart during the project one may speculate whether EuroPart respondents would have provided a much more negative picture. In fact, one of the reasons why data were very difficult to obtain from EuroPart could well be that EuroPart respondents were reluctant to paint a negative picture of their experience to an 'outsider'.

When asked to comment on possible ways to improve how the activities were managed in the future, one of the issues that was raised by several EuroPart respondents was the lack of size and resource of EuroPart, preventing attempts to manage activities beyond first tier suppliers. Some respondents acknowledged that alliances with other suppliers would be one way to overcome this obstacle, thus reducing EuroPart's dependency on powerful customers and allowing it to take a higher degree of control over its own actions and strategic direction.

Finally, an attempt has been made to map the level of collaboration amongst the key actors in the case. Figure 22 shows the researcher's interpretation of the level of collaboration displayed within the conduct of each activity. Whereas this can only serve as a crude indication, it highlights some of the perceived levels and variations of collaboration within key relationships.

[94] Some respondents regarded this activity as Not Applicable

[95] The European JV respondent was not in a position to comment on output performance.

Figure 22. Extent of Collaboration in Key EuroPart Relationships

	Non-Collaborative	Collaborative
Uniting	- Dictation - Formal vendor assessment procedure	- Joint choice - History & trust important
Timing	Involved in detail engineering or later	Involved in idea generation or concept development
Mobilising	- No sharing of development costs - Individual goals	- Sharing of development costs - Shared goals
Communicating	- Non-transparent exchange of information - One-way flow	- Transparent exchange of information - Two-way flow
Exchanging HR	No allocation of engineers to project	Engineers allocated to project
Synchronising	- Imposed project plan - Isolated technology development	- Agreed project plan - Alignment of technology development
Knowledge exchange	- Non-transparent exchange of knowledge: responding to specification - One-way flow	- Transparent exchange of knowledge: Joint development of specifications - Two-way flow

EuroPart – J-Car/Customer Relationship
EuroPart – J-MasterPart & J-Car Commerce Relationships[96]
EuroPart - ToolMaster

Figure 22 highlights the low degree of collaboration across key relationships. Hence, despite the fact that when the case study was initiated it was described by EuroPart managers as being representative of a project of a collaborative nature, the findings indicated that, when described according to the collaboration activities, collaboration was generally low. An important explanatory factor was that EuroPart would have liked to believe that it was a strategic supplier to the customer, whereas in reality this was clearly not the case. Interestingly, J-Car stated that it was very likely that EuroPart would be involved more closely in future projects.

An important methodological lesson from seeking to describe EuroPart's level of collaboration with its key suppliers and customer(s), was that the exercise was constrained by EuroPart, as the focal company, being seen by its customer as a non-strategic partner, whereas some of the focal company's suppliers clearly acted as strategic ('first tier') suppliers to the customer in Japan and were therefore more collaborative relationships. Hence, the project when viewed from the customer's perspective involved extensive collaboration with several suppliers. However, the focal company in this case study did not happen to be one of these, even if the focal company liked to believe that it was.

[96] J-MasterPart generally less collaborative than J-Car Commerce

7.1.5. Lessons and Conclusions from Fuel Tank Project Case

The analysis of this case study has revealed some of the ways in which the network affects individual collaboration activities, both positively and negatively. The complexities of the network, not least in terms of direct activities between otherwise indirect suppliers and customers, have shown some of the problems EuroPart faced trying to manage the project effectively and collaborate with suppliers and the customer in the best possible way. The findings indicate that EuroPart was in a very difficult position during the course of the project, trying to cope with suppliers who were not of their own choice; this was an example of a network intervention strategy applied by J-Car. The findings indicate that this caused more problems than benefits from the point of view of EuroPart and its attempts to interact effectively with a number of key suppliers and customers. It also seemed to cause an atmosphere of much tension and conflict in the relationships amongst some of the key actors.

Most importantly, the activities of uniting, mobilising, communicating, exchanging knowledge, and synchronising, were constrained by the network. They were constrained in the sense that EuroPart lost the control over the management of those critical activities which would have allowed it to engage in close collaboration with key partners of its own choice. Timing, however, did not appear to be negatively affected by the network in this case. The effect of the network on exchanging human resources is difficult to assess in this case as this practice did not appear to have taken place to any great extent in the relationships examined here.

Conversely, the network enabled several activities at the same time as constraining them. The primary responsibility of one supplier was to perform as a sourcing or access function; this enabled the process of uniting for EuroPart as it allowed it to connect with suppliers it would otherwise have found difficulty in mobilising. History generally functioned as an enabler rather than as a constraint in terms of the importance of suppliers being able to show a track record of having worked for a range of customers. This was seen as a key factor in suppliers winning the business, as the customers in this case deliberately wanted to engage with suppliers who had experience of other customers to assist learning across relationships. Timing was also enabled by history in terms of some actors learning from previous experience that early involvement was paramount to prevent problems. These historical impacts however were possibly not so much a question of *path* dependency but rather *past* dependency. The network further enabled communicating and exchanging knowledge as it provided access to information and knowledge which EuroPart would not otherwise have been able to obtain. Its strategy for using the network as an enabler seemed to be characterised by 'networking' as a way of gaining access to resources within the network rather than deliberate attempts to influence or co-ordinate relationships. The co-ordination that was evident in this case mainly took the form of intervention from the vehicle assembler, leaving EuroPart largely to cope with the network being controlled by a powerful customer rather than it seeking to take any deliberate strategic action to control the network. There was limited evidence of any explicit attempts to apply dissemination strategies, although implicitly such a strategy might have been used to manage, for example, timing, mobilising, and synchronising.

The case study of the fuel tank project provides an analysis of network effects on individual collaboration activities undertaken in connection with a product innovation project. The effects were primarily negative in this case, implying a lack of both operational and strategic control for the focal company in this case, the most important strategic decision faced by EuroPart did not seem to be whether or how it could avoid being in this network, as the only way it could leave 'the network' would be to terminate the customer relationship. The critical decision seemed to be for EuroPart to re-define its strategic position within the network to take full control of its business. The importance of modular or full systems offerings thus emerged as a particular theme in the pilot case and seemed to impact on the likelihood of network co-ordination strategies, such as intervention, being applied. The perceived capabilities of suppliers, such as EuroPart, seemed to constitute an additional contextual feature of the pilot case. This implied that competence trust in suppliers might be an important factor in explaining different patterns of network co-ordination across the four cases.

There were several important lessons from the pilot case. Methodologically, the case highlighted a number of problems in the performance assessment exercise. One such problem was the subtle yet important difference between what effect each respondent believed each activity *did* have on performance and what he or she believed each activity *should* have. Thus, the fact that respondents were supposed to complete the questionnaire independently was seen as risky as the questions could be subject to interpretation. Hence, the performance questionnaire was simplified and moved into part of the interview guide to resolve this problem.

A conceptual problem was also identified. The most serious problem concerned the activity 'knowledge exchange'; this revealed very limited additional information compared with communicating. 'Technical engineering knowledge', for example, was also discussed under exchange of 'design ideas and concepts', as both related to exchange of drawings and design specifications. As it began to emerge that another potentially important activity, 'problem solving', had not been included, it was decided to substitute exchanging knowledge with problem solving. This decision was sparked by the many conflicts and problems experienced by EuroPart in its key relationships and was upheld by a literature investigation, which identified problem solving as an important element of successful collaboration (see Chapter Four for details).

The pilot case further provided examples of the nature of different forms of network constraint. Particularly, the role of customer intervention as an administrative or logistical dependency, and thus a constraint, was highlighted. Network intervention was conceptualised as an enabler, but emerged equally as a network constraint. Methodologically, this duality signified that one of the problems of a focal firm network perspective is the difficulty in capturing the perspective of several actors. An equally thorough perspective of the customer when the focal firm is a 'first tier' supplier is arguably important, including being able to capture the 'project' from the perspective of the focal firm, when the focal firm's project merely forms part of a customer's, or assembler's, project. However, it was decided not to make such a fundamental conceptual and methodological change due to the practical complexities of conducting non-focal firm network research. Furthermore, it was decided not to limit further case studies purely to assemblers to be able to capture some of the negative consequences of administrative or logistical dependencies, such as network intervention, on collaboration activities.

Furthermore, the pilot case indicated some of the problems of conducting research on 'collaborative' relationships. The pilot case had focused on 'key' relationships in terms of high value and volume, assuming that these would be collaborative. However, the fuel tank project case showed that it is very possible to have a relationship, which is very 'key' but entirely non-collaborative, such as the relationship between Europart and

J-MasterPart. In addition, a focal firm is likely to describe its relationships as collaborative, but the analysis of case study data may show that relationships are largely non-collaborative. Therefore, an intention to examine a project involving high degrees of collaboration becomes problematic. Furthermore, any innovation project will involve a portfolio of relationships of different degrees of involvement and arguably this is a feature of successful projects. Hence, a generalised view of a project as either collaborative' or 'non-collaborative' is arguably dubious, even if some projects entail different degrees of collaboration when 'aggregating' relationships. To cope with this problem, it was decided to incorporate a screening exercise as part of the initial contextual interview with the focal firm to try to ensure that even if not all relationships would be collaborative, at least some of these would have collaborative characteristics.

The pilot case showed that the ambition to concentrate on projects involving a high degree of innovation in the form of new or first time technology application would be problematic. The reasons for this problem were similar to the reasons why 'collaboration' was difficult to capture. Respondents are likely to believe that their project and technology is innovative. In the pilot case the high degree of innovation was emphasised by the first respondent/main contact and only later emerged as an exaggeration.[97] The actual degree of innovation that characterised the pilot case is also likely to have influenced how the project was managed. Therefore the findings on collaboration activities are likely to have been influenced by the lower degree of innovation than intended. Consequently, it was decided to attempt to focus on 'innovative' projects (incorporating first or second application of new technology) in the further case studies, although it was recognised that this could prove to be difficult given the tendency for respondents to believe in the innovativeness of their own technology.

Finally, the nature of the focal company in the pilot case indicated the importance of choosing cases in which the focal company possess the necessary information and knowledge about all stages of the chosen project and all activities. The pilot case had been restricted as a result of the focal company being a manufacturing JV, which was not itself involved in the early stages of the project whereas, for example, its European JV partner was involved much earlier. Following the pilot case it was contemplated

[97] The first respondent emphasised that the current project reflected the 2nd application of the new technology, which had not been applied by any other company to date.

whether the best way to ensure a high level of focal firm respondent awareness and knowledge, would be to focus on focal companies with headquarters and/or R&D departments in the UK. The difficulty of such an approach, however, was recognised, as most large innovating companies are international, and thus very likely to have internationally or globally dispersed operations. Nevertheless, it was decided that caution should be taken that focal companies at least were not distant arms of foreign operations.

7.2. Asian Car Development Project

7.2.1. Context

This is the story of an innovative vehicle development project aiming at high volume sales in a Far Eastern market. The case is predominantly seen through the eyes of a company, which shall be referred to as 'Auto-Engineer'. It acts as the focal company in the case and provides engineering services to the automotive industry. It has links to motor racing and is seen by many people in the industry as a pioneer in new technology and innovation. AutoEngineer generally operates as a 'first tier' supplier to vehicle manufacturers; however, its role is not easy to categorise. For example, it may become involved in production through turnkey arrangements with vehicle manufacturers; one such turnkey project is the subject of this case study. [98]

The project that is the focus of the case study involves the development of a new car, which is to be built at a new Asian plant. The car is to take advantage of the first high volume application of a new car body material. The customer is a joint venture (JV) between a global vehicle manufacturer, hereafter referred to as 'VM' and two Asian parties. One of these parties is the Asian manufacturing plant; the other is a government body. AutoEngineer's role in the project is to perform the styling, engineering, product development, and verification testing, ensuring that all aspects of the vehicle meet the agreed specifications. The project set-up is thus a turnkey arrangement. This is therefore a very extensive and demanding role for AutoEngineer and the project is regarded as being of strategic importance to the future of the company.

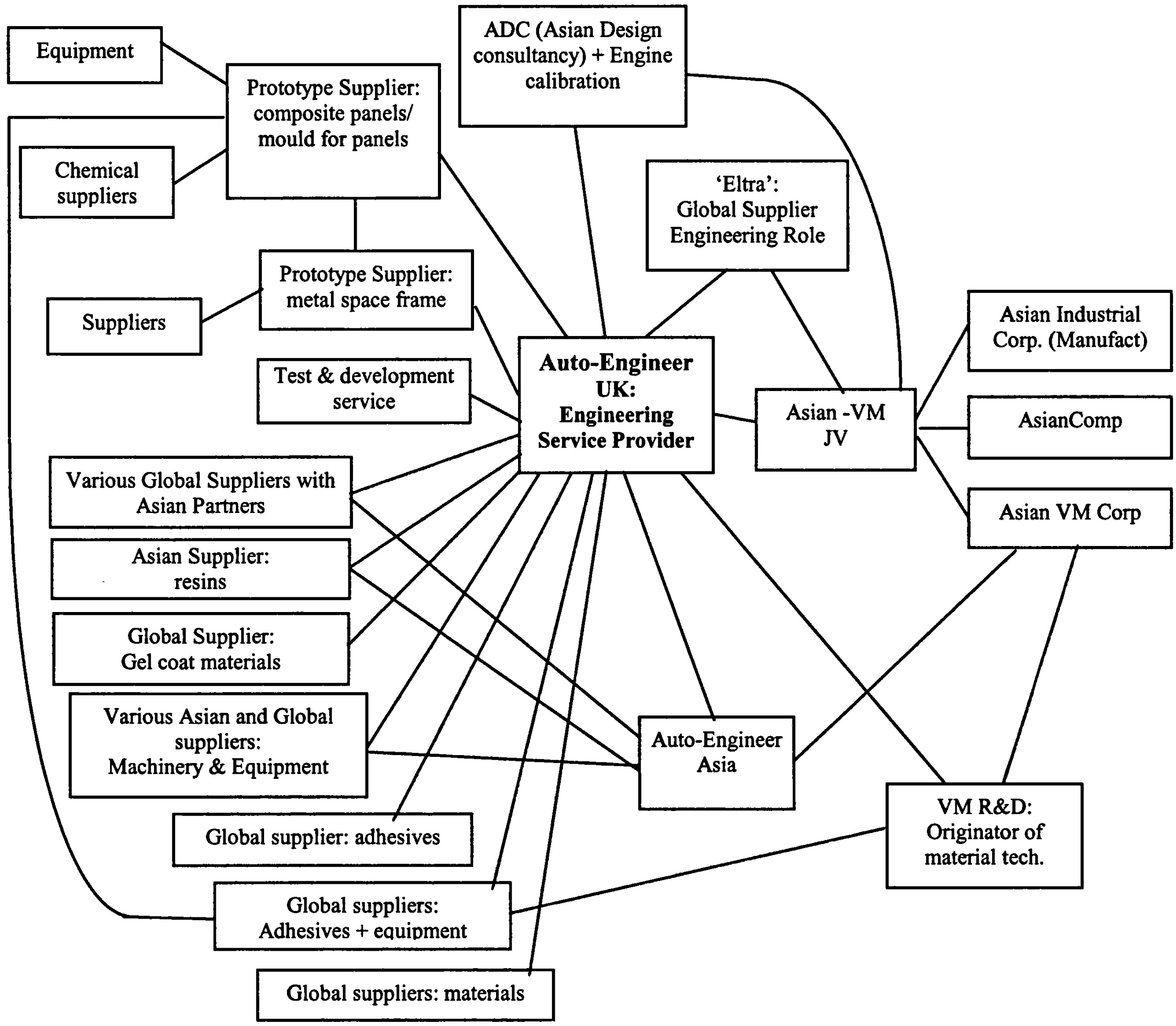
The innovation element in the Asian car development project case is two-fold. Firstly, it contains a technological innovation by applying a new material, which has not been applied to date in volume car production. The inspiration for the material stems from outside the automotive industry from the boats and bathroom industries. Hence, the material is not a new innovation, but it presents an innovation in the automotive industry, as it is being applied in a vehicle design for the first time in the world; several

[98] A turnkey project is a project in which the contractor has responsibility for completing all aspects (e.g. product design, development, sourcing, factory and process layout design) leaving the customer with a system that requires him simply to 'turn the key'.

patents are pending from the project. The vehicle, though, is a standard 'clone' of an already existing car, the only technological innovation in the project concerns the material. Secondly, the project is an organisational and market innovation because it entails AutoEngineer entering a new market in a region of the world in which it has had no historical experience. The project reached production ramp-up in the summer of 2002. At the ramp-up stage AutoEngineer was to cease its involvement, handing its engineering role over to a company here referred to as ADC (see later).

The structure of the network is illustrated in Figure 23. Some components are included, although actual names of companies have been made anonymous. The map identifies the main actors involved and their contributions to the project, including parts developed/to be supplied. It is a complex network of relationships in which some actors have a role in production and supply but others only in innovation and development.

Figure 23: Asian Car Development Project: Network Map



The map is drawn from the perspective of AutoEngineer, which is therefore positioned in the centre of the network. AutoEngineer has the overall engineering responsibility for the vehicle. The JV and its constituent parties are positioned in the right hand side of the map. VM's R&D department, which is the originator of the material technology to be applied in the project, provides a central link to the JV in addition to AutoEngineer and the production suppliers. Suppliers are depicted on the left of the map. Prototype suppliers constitute one category in the top left hand corner: these have limited experience of high volume production, but are considered 'key players' due to their particular knowledge of the technology applied in low volume racing car production. Production suppliers, as the other category, are in the bottom left hand corner. Only a selection of the total body of the latter is included in the diagram. AutoEngineer has a particular responsibility for the machinery and equipment suppliers, managing the transfer of concept designs to detailed drawings, and sourcing all the necessary equipment.

The role of two actors should be highlighted as they have particularly central roles in the project: 'Eltra' and 'ADC'. 'Eltra' is a global first tier systems supplier. It originally sub-contracted the design to AutoEngineer. On completion of the design work Eltra's UK branch is to transfer all its responsibilities to its Asian branch. The Asian branch will then assume the engineering responsibility in Asia, together with the manufacture of its system as a normal first tier supplier. It is, therefore, in one sense a customer of AutoEngineer, although AutoEngineer's commercial agreement is with VM. ADC is a design consultancy based in Asia. It is a joint collaboration between VM and the Asian Industrial Corporation. ADC conducted the initial styling and produced the original basic concept car. During the course of the project it assumed the responsibility for a variety of engineering tasks, including engine calibration. ADC is to assume the full product engineering responsibility for the vehicle once it reaches production, at which point AutoEngineer's role in the project is to be withdrawn.

The activities that took place during the course of the project as part of the management of the relationships shown in Figure 23 are to be discussed in the following section.

7.2.2. Collaboration Activities

This section reports on the findings on the set of collaboration activities. The findings from each activity are reported sequentially. The sub-sections describe the nature of each activity from the perspective of the different actors, and examine the evidence of the different ways in which the network may have enabled and constrained the conduct of each activity.

Uniting

As the case concerned a complex project there were, not surprisingly, a large number of actors that became united for the purpose of the project and, for some suppliers, the subsequent vehicle production. Interestingly, the process of uniting took a noticeably different form in two main types of relationship, namely production suppliers and prototype suppliers.

Regarding the process of uniting between AutoEngineer and production suppliers, it is a defining feature of this project that AutoEngineer was never supposed to act as a customer to these; it was to have no traditional first tier involvement in component production and supply. AutoEngineer's turn-key role was to identify potential suppliers on behalf of VM, as it did not yet have an infrastructure in place in Asia.

AutoEngineer's uniting with the production suppliers initially took a conventional form of supply market research, not least in Asia, and subsequent compilation of a list of technically competent vendors. However, the qualitative data revealed that the number of actors, and hence decision-makers, involved in the process at the end of this stage, transformed 'uniting' from what should have been a smooth selection process into a rather confusing and conflict-filled adventure. The confusion began when VM expressed dissatisfaction with AutoEngineer's list of suppliers, stating a preference for low cost sourcing rather than technical competency. Another actor, the Asian part of the JV customer, added to the tangle by expressing a preference for local Asian suppliers.[99] The end result consisted of a combination of several lists and preferences, and was thus to some extent consensus-based, albeit somewhat chaotic.[100]

The uniting of AutoEngineer with its prototype suppliers was influenced by fewer actors and was therefore less complicated. These suppliers became involved through an invitation to quote, giving these 'a foot in the door'. As such, the process seemed to be slightly less formalised and procedural compared with the production suppliers (as will be discussed in the following section). The process of uniting of AutoEngineer and VM took place in a similar fashion. AutoEngineer had been involved in a previous relatively small project to construct an engineering evaluation vehicle, which was used to assess the application of the new technology into a vehicle production project.

Therefore, the concept of uniting - rather than, say, supplier selection - seems to reflect the interactive and almost chaotic nature of how this activity was conducted.

[99] A local presence was required for the following reasons: local sourcing in Asia implies the preferential grants and subsidies; it saves on customs, duty and shipping costs; Asian manufacturers are required to demonstrate a percentage of local sourcing.
[100] Respondents from different companies demonstrated divergent normative perceptions of the supplier selection process e.g. AutoEngineer was used to a formal rational process whereas VM seemed more content with a more 'emergent' process.

Network as constraint on uniting

The previous section outlined how the process of uniting had been less than smooth. This section presents the analysis of uniting, which highlights a number of ways in which the network impeded the process.

The first type of 'negative network effect' related to different forms of dependency. The first of these was path dependency. Path dependency seemed to have an impact on the process of uniting of AutoEngineer and the prototype suppliers. Path dependency was evident in the form of the historical relationships between the parties. However, this effect was not, as conceptualised, a constraint on the process but rather an enabler: [101]

> *I have worked with them in the past. I know that you give them a job and they will deliver the job on time, on cost, which requires little involvement from engineers here to follow-up and to chase and to make sure they're doing the job correctly.....*
> (AutoEngineer Technical Leader)

The rationale for choosing the two existing prototype suppliers was primarily to reduce the inherent risk in the project. The level of risk was high, as it was the first application of the new material in a high volume car. The uniting of AutoEngineer and VM seemed to follow a similar pattern. Hence, in this case path dependence, in the shape of historical relationships, actually enabled the process of uniting by making it less complex and risky.

Another form of dependency appeared to relate to VM's practice of intervening in the sub-supplier selection process through specification or nomination. AutoEngineer indicated that VM's intervention was not as strong as it would have been, had it been in a more established position, for example, in one of its Western markets. Nevertheless, VM decided to intervene at the very end of the supplier selection process, albeit in a collaborative rather than a controlling manner:

> *They never really dictated anything. They were always involved in the discussions and agreed the selection and the route forward. There hasn't ever been a case where [AutoEngineer] was just told, "you will do it". It has always been with some discussion and debate and compromise on both parts.* (AutoEngineer Business Unit Director)

[101] The historical relationships were in fact with AutoEngineer's sister company.

There was further evidence of another form of network constraint as some suppliers were deliberately avoided due to their network relationships and consequent confidentiality concerns:

> *There were some suppliers that were deemed unsuitable because of their existing contacts, their dependency on other organisations, competitors to VM. There was a fuel tank supplier that we were unable to work with because of their link back to [a competitive vehicle manufacturer]. There were some other suppliers where we would have had to have given them information about the technology in order for them to make the parts and they were also related to [other competitive vehicle manufacturers].* (AutoEngineer Business Unit Director)

The vehicle manufacturer echoed this concern:

> *In effect there were some people that expressed concerns about me involving [Eltra] at that time because their break with [another vehicle manufacturer] had been very recent. In fact we had discussions with some of the [Eltra] people to make sure that it was clearly understood what the confidentiality issues were.* (VM)

These two quotes illustrated that it was the dependency between Eltra and its traditional customer, which caused confidentiality concerns in VM. This was therefore an example of how inter-dependent bonds between a supplier and different customers can create problems of loss of knowledge from one customer to the other via a common supplier. In the car development case confidentiality concerns evidently had a constraining effect on the process of uniting, as AutoEngineer deliberately avoided some suppliers as a direct result of network inter-connections.

Thus, the network seemed to constrain the process of uniting in several ways. There was evidence of administrative or logistical dependency in the form of some degree of network intervention by the customer, albeit relatively minor and to some extent consensus driven. AutoEngineer deliberately avoided several suppliers due to their links to inter-connected customer-supplier relationships and associated fears of valuable knowledge dissipating to these actors. Path dependence actually enabled the process of uniting rather than constraining it.

Network as enabler of uniting

Although the network clearly constrained the process of uniting in several ways, as explained in the previous section, it enabled it at the same time.

Before the Asian car project, AutoEngineer had not had a direct relationship with VM. It was, in fact, through the network that AutoEngineer became involved in the project. The access in this case was provided through VM's subsidiary in the Far East, which had a strong historical link to AutoEngineer as it managed one of its divisions. Curiously, VM had a European subsidiary, which would have been a more obvious choice. However, it had a much better relationship with its Asian subsidiary and decided that it would be easier to build a relationship with AutoEngineer through that company rather than its European subsidiary.

In addition to the network enabling the process of uniting by one actor providing access to other actors, there was evidence of deliberate network co-ordination of uniting. This happened on a small scale when AutoEngineer co-ordinated the prototype and the production suppliers. The co-ordination of the former was not least to minimise the inherent risk of the project:

> *We asked [one of the prototype suppliers] to work with two companies who they knew and they had worked with before and they had a very good relationship. Again, it was spreading the risk. We felt that the project needs to have the risks spread out because no one company was capable of doing the whole job within the time-scale.* (AutoEngineer Technical Leader)

The co-ordination of the production suppliers took the form of nomination of sub-suppliers. Although there were varying perceptions on this issue, some indirect nomination of sub-suppliers appeared to have taken place by virtue of the design by making part specifications very particular:

> *There is a fairly strong logic that says the person who holds the pencil actually holds the supplier selection as well because the person who does the design work can actually dictate who can make that part. So what we did was we ensured that where we found it important to use a particular supplier or that supplier's component, the best design was drawn up using that component..... So it was probably a little bit sneaky to do it that way but rather than have a fight with the joint venture and impose our will upon them*

> *we took the view that the same result would be achieved by designing the vehicle around those standard parts..... We didn't specify those indirect suppliers, we specified which components had to be used and because they had a very limited tooling and development budget they were hamstrung – they could not then justify going and copying that part at another supplier.* (AutoEngineer Business Unit Director)

This quote showed that AutoEngineer saw it as imperative to control certain parts, and mainly safety-critical parts. Had AutoEngineer been more influential it might have attempted to take even more control over parts that it regarded as 'critical'.[102] Intriguingly, the level of control may reflect an apparent shift in the responsibility of 'uniting' of network actors in terms of nomination of key suppliers. One of the respondents argued that it was increasingly large 'first tier' suppliers rather than vehicle manufacturers that decided on this 'network design issue':

> *I don't think it is [the vehicle manufacturers who specify the supplier network], any longer. Certainly the Japanese transplants in Europe and more and more the other European suppliers..... will decide that they want a steering wheel that performs to a certain number of prescribed measures.... and select the supplier for that - then that tier 1 or tier 0.5 supplier has the responsibility to then cascade those requirements down through the supply chain. It used to be the case where [vehicle manufacturers] would actually go down to the last nut and bolt in order to understand it. But now I think that's less and less because the vehicle manufacturers have become more assemblers...[with major tier 1 suppliers] who perhaps take that responsibility on. But that wasn't possible in [Asia] because they're not developed enough to be able to do that.*

The need for either the vehicle assembler or a major supplier, such as AutoEngineer, to influence the design (or constitution) of the supplier network also appeared to be related to the nature of the product.[103] The vehicle was to be a low-cost and low-specification car, despite the application of the new technology. One of the AutoEngineer respondents suggested that its strategy would have been to specify more sub-suppliers through parts specification had the technical specification level, or part criticality, been higher.

[102] There was also an attempt to use as many existing parts to reduce cost.
[103] Supply network 'design' in terms of choice of key suppliers at different levels.

The responsibility for sub-supplier nomination as a form of network effect, thus seemed to be affected by a number of factors: the criticality of the part and the technology, the sophistication of the offering, and the level of influence of the vehicle manufacturer relative to the 'first tier' supplier. One may deduce that had the project aimed to develop a sophisticated vehicle containing a large amount of new technology, AutoEngineer, as a relatively powerful 'first tier' supplier, would have specified a large part of the supplier network to reduce the inherent risks of any new technology applications.

Timing

As with *uniting* it is important to distinguish between the timing of involvement of production suppliers and the timing of involvement of prototype suppliers.

The prototype suppliers were involved from the outset of the project during the transition from concept development to basic design. They contributed to the early detail design and the initial feasibility study together with AutoEngineer. Thus, AutoEngineer became involved with VM during its concept development, to complete the final feasibility study, and involved its prototype suppliers more or less immediately afterwards. Interestingly, in one way AutoEngineer became involved in the project prior to VM's own involvement, as it did not have a project team in place until six months after AutoEngineer became involved. Apparently, the explanation for VM's late involvement was, according to one AutoEngineer respondent, that VM never really believed the project would continue beyond concept development.

The production suppliers became involved much later in the project. Their late involvement was not least a result of the divide between the production suppliers and the prototype suppliers. This was much to the frustration and concern of AutoEngineer, which feared that the production suppliers would consequently be poorly positioned to assume the control of the eventual production task. AutoEngineer therefore sought the involvement of the production suppliers sooner rather than later.

Network as constraint on timing:

The interviews with internal and external respondents revealed very few negative network effects on the process of timing. There were no apparent effects of path dependency on the timing or moment of actor involvement in this project.

However, one network dependency factor constrained the moment of involvement. This concerned the problems the joint venture parties faced in finalising the JV agreement. The three joint venture parties could not reach an agreement on the composition of the JV contract, struggling to agree the roles and responsibilities and obtain the commitment of VM Headquarters to the project. Furthermore, according to AutoEngineer, parts of VM lacked the commitment to the project, because they did not believe the project would actually proceed. These problems, which were outside AutoEngineer's control, prevented AutoEngineer from involving the production suppliers at an early stage. Thus, the joint venture agreement and the apparent lack of internal VM commitment had important administrative or logistical dependency effects on the process of timing; these seemed to be of a 'legal' nature as they concerned the drawing up of a JV contract.

Network as enabler of timing:
There was little evidence of positive network effects on timing. Several respondents proclaimed that neither AutoEngineer nor VM sought to influence the timing of production sub-suppliers' involvement. The Business Unit Director explained that the barriers to influencing sub-supplier timing were not only the geographical distance between AutoEngineer and the production suppliers, but also the capabilities of the production sub-suppliers:

> *No we didn't [seek to influence the timing of sub-suppliers involvement]. It was very difficult from a practical point of view. The lower down the supply chain you go in [Asia], the less and less technical capability, language capability, CAD systems etc. It was very difficult to involve them in the development process.*

According to the Technical Manager, AutoEngineer did, however, encourage the involvement of the prototype sub-suppliers' involvement. VM's view of the timing of sub-suppliers' involvement was largely consistent with the other respondents. VM did not seek to influence at what stage AutoEngineer was to involve its suppliers but left that to AutoEngineer to decide. Interviews with the prototype suppliers did not expose any network effects on timing.

Hence, overall the main network effects on the process timing in this project related to the administrative or logistical dependency caused by problems in finalising the JV agreement.

Mobilising

One of the notable themes in this project was that suppliers at different levels expressed a high degree of dissatisfaction. One of the apparent explanations for the dissatisfaction was the lack of ground rules, establishing e.g. roles and responsibilities. Several AutoEngineer respondents expressed strong concerns about the problem of lacking ground rules:

> *There were absolutely no ground rules and if we're being 100% honest, the rules that we established just about changed by 100% and changed on a daily basis. Without doubt it is the most ill-disciplined, fragmented programme I have ever worked on in my career. .... Not only have the ground rules changed on a very regular basis – the strategy, everything has changed – also the partners have changed, the people involved from the customer side with two exceptions have all changed...... And each person has brought a new strategy to the programme......... You can tell the strength of my feeling on this subject. It has been an absolute nightmare.* (AutoEngineer Business Unit Director)

The quote illustrated the atmosphere of discontent and frustration, but also highlighted the perceived importance of having clear ground rules regarding actor roles and responsibilities, as clear ground rules provide a foundation for the otherwise complex and dynamic task of mobilising and managing an innovative vehicle development project. It also showed how frequent changes of staff within a project team can cause mobilisation problems.[104] The analysis indicated, however, that some of this frustration was related to different individuals in different companies having widely different perceptions of the required level of detailing in ground rules and roles and responsibilities. It was apparent that VM's preference was less detailing of responsibilities, whereas AutoEngineer constantly fought a battle to obtain a higher level of detailing. This conflict provided an example of the consequences of different actors having different views and ambitions within a network and again signified how

[104] A large number of engine changes (and thus associated changes) coincided with the people changes and added to the apparent frustrations.

the atmosphere in the AutoEngineer-VM relationship was one of friction and even frustration.

Network as constraint on mobilising:

Apart from the issue of different actors having different views and ambitions within the network, there were also other constraining network effects on mobilising. Path dependency seemed to pose no constraint on mobilising, however, an important network constraint pertained to the difficulties in setting up the JV, or an administrative or logistical dependency of a legal nature. These downstream complications created problems further upstream as sub-suppliers had to cope with frequent unpredictable technical and strategic changes. Thus, it was not only the administrative or logistical dependency but also the technological dependencies in relation to changes in engine and power train. The extent of these technological dependencies and their effect on AutoEngineer's mobilisation is evident from the quote below:

> *When the programme started originally, it was going to take [a 1.1 litre] engine and gearbox. That was in the first engineering evaluation vehicle. And the deal to buy [this] never happened.... So that was just scrapped, after we had built the first cars and done the first round of design. It was then changed to [a 1.6 litre] engine and gearbox but [that was subsequently ditched]. These phases are for three and four months. We were then directed to use a [1.5 litre engine and gearbox]– we saw the engine etc, got all the design information, redesigned the frame to accommodate the front suspension, drive shafts etc that came with the engine, redid it. The target was three months. We were asked to compress it to shorten any delays to the programme, we compressed it into eight weeks of late nights and weekends, and then [the vehicle manufacturer] decided they weren't prepared to sell the engine to VM. So that got scrapped. Then a [1.3 litre engine] was scrapped within a couple of weeks. Then we went to another 1.4, which was a sleeved version of the [1.6 engine] with [another] gearbox – never been done before and we had to design the interface. Five months ago, VM [for legal reasons] asked us to go to the 1.6 litre engine, which was the second engine of the six that we had been through. But every time you did this you had to change the suspension and the frame and everything else.* (AutoEngineer Business Unit Director)

Thus, there were very significant technological dependencies in this case, which had a strong effect not least on mobilisation. Interestingly, whereas the technological dependencies had a negative effect on motivation amongst the prototype sub-suppliers it also had an adverse positive effect:

> *It almost got to the point though where effectively AutoEngineer and the prototype suppliers developed some sort of siege mentality where regardless of the amount of pain everybody kept laughing because it was actually funny. One of the groups of engineers was actually running a book on what day or time the next major change of programme direction was going to be. So they developed some form of camaraderie around it. VM, if you like, by virtue of the problems they had in forming the joint venture in technical directions, it actually created a much stronger team elsewhere.* (AutoEngineer Business Unit Director)

This quote illustrated how the team quickly learned to cope with the frequent changes in technological and strategic direction. It also seemed to reflect an 'us versus them' mentality which suggested an atmosphere of dissatisfaction and conflict.

Network as enabler of mobilising:
There were no apparent positive network effects on mobilising where the network actually enabled the process of mobilisation. AutoEngineer did not seek to influence how its suppliers mobilised their suppliers and VM apparently had the same attitude. The only issue brought up by the VM respondent was that he had encouraged suppliers to ensure that the overall goals of the project were clear. One AutoEngineer respondent implied that AutoEngineer had not attempted to influence mobilising of sub-suppliers due to the high degree of carry-over in design and parts. Thus, one may speculate whether AutoEngineer would have managed sub-supplier mobilisation differently had the vehicle design sought to incorporate a higher degree of new customised components (as opposed to existing off-the-shelf components). Thus, again there may be a link between the degree of necessary 'network co-ordination' and the nature and sophistication of the offering to be developed.

Communicating
The communication between VM and AutoEngineer mainly took place via the VM vehicle integration manager, who was placed on site within AutoEngineer as a "keeper of the faith". In addition, there was a very high degree of electronic communication in this project and frequent meetings. These included styling review meetings or "clinics" where AutoEngineer presented its ideas and concepts to VM.

The perceptions of the extent to which the actors had communicated different forms of information and knowledge varied widely. AutoEngineer perceived VM as unwilling to commit to policy and procedure information; hence this was, apparently, limited. In addition, communication of actor performance e.g. between VM and AutoEngineer seemed to be limited, although the perceptions of performance information varied. AutoEngineer believed that it had received purely anecdotal feedback from VM, but had provided weekly reports on project progress.[105] In contrast, VM's perception of the pattern of performance feedback was that it had provided both frequent and extensive performance feedback to AutoEngineer, albeit not formalised. Intriguingly, the prototype suppliers also stated that they had neither received formal performance feedback from VM nor from AutoEngineer.[106] Hence, the perceptions of the required level of detail and formality in communication varied widely amongst different actors.

The two prototype suppliers were closely involved in design reviews and on site at AutoEngineer approximately two days a week. Conversely, the Asian-based production suppliers had relatively limited involvement in the communication loop due to their late engagement in the project. They also had limited influence on the design, although AutoEngineer perceived the production suppliers as very keen to learn from the project and all the actors involved.[107] However, the strong desire of the production suppliers to learn exacerbated the level of confidentiality within the project team. This meant that there was a divide between those actors, who had signed confidentiality agreements, and thus received extensive information, and those who had not signed confidentiality agreements and consequently received very limited information. However, this division also meant that AutoEngineer was concerned that knowledge and experience, gained from working with the prototype suppliers, would never be transferable to the production suppliers:

> *[As a consequence of having separate production and prototype suppliers] you are not making the best use of the knowledge you've gained because the AutoEngineer engineers will never capture all of the knowledge. They will capture all of the knowledge of how the vehicle goes together but not all of the knowledge of how the*

[105] In fact, AutoEngineer respondents stated that they had attempted to persuade VM to complete their customer evaluation form, but unsuccessfully – apparently due to VM resource constraints.
[106] A similar source of discontent concerned VM's unwillingness to listen to AutoEngineer's suggestions.
[107] Substantial language problems and a cultural barrier hindered the process; most of the Asian suppliers were SMEs and an interpreter was often required.

> *parts are manufactured, the areas to pay particular attention to etc.* (AutoEngineer Business Unit Director)

Thus, it seemed that although communication in some respects was very open and extensive amongst the main actors involved, some respondents were concerned that the strong divide between actors could result in knowledge transfer (and thus ultimately manufacturing) problems. There were also considerably different perceptions of the extent to which communication had been - and *should be* - formalised. The clash in management styles seemed to be a source of frustration.

Network as constraint on communicating

The administrative/logistical and technological dependencies concerning the joint venture agreement problems constrained communication between the essential parties involved in the project. This was not least manifested in AutoEngineer's struggles to obtain information regarding manufacturing details from VM, thus ultimately a technological dependency. Furthermore, VM's struggle to develop and manage its strategic alliance partners and subsidiaries affected communication. The AutoEngineer Project Manager explained:

> *A lot of the way forward – at the time – was hinged on our not having to engineer the platform. They couldn't build this strategic alliance with [another vehicle manufacturer] to let us have this engine, gearbox and suspension from their partner in [Asia]. So their own building of relationships within their own strategic alliances led to us not having information, which we are used to.... the engineering for it and all the CAD data was done [by VM's subsidiary] and we are not allowed to have that, which we find very strange..... When they came to us and did the sell for us to quote to, they assured us all these partnerships were in place.*

Apart from the administrative or logistical and technological dependencies, path dependency also affected communication patterns. Path dependency was evident in the form of historical relationships between AutoEngineer and other vehicle manufacturers that, according to the VM respondent, traditionally had been strained. The VM respondent perceived the historically strained AutoEngineer-vehicle manufacturer relationships as having initially influenced the extent of communication problems between VM and AutoEngineer, as a basic level of trust did not pre-exist. VM appeared to be keen to establish 'open book' communication within key relationships but to restrict the level of communication outside those relationships. In fact, there appeared to be at least three levels of involvement: 1) The AutoEngineer project team which was fully informed even about the core material technology developed initially by VM R&D; 2) other key suppliers (primarily on the prototype side) which were informed about most aspects although not core technology issues; and 3) all other actors involved which were informed purely on a need to know basis:

> *We have had to be quite careful with the information that we have given to our 1st tier suppliers and the time at which we gave them that information and the level of the information. We gave them what they needed to know when they needed to know it rather than divulging everything because we needed to protect the confidentiality of our customer. There came a time in the programme where we needed to expand on that and then we gave them the bare bones to start with, followed by a little more information, protected with confidentiality agreements..... We have protected quite religiously the [core material technology]. ...AutoEngineer and the R&D department are the only ones who know [the composition of those materials].* (AutoEngineer Manufacturing Manager)

The issue of path dependency was thus closely related to the second main form of network constraint: risk of dissipation of knowledge. Interestingly, the need to keep certain issues confidential seemed to be mostly in VM's interest, as AutoEngineer did not regard the technology to be its intellectual property. Nevertheless, AutoEngineer believed that VM would have kept more details confidential within the key relationships, but that AutoEngineer wanted it to be open due to the fragmented nature of project:

> *.....It was such a fragmented programme that you had to take the view that everybody had to be involved all of the time otherwise one of the elements would have fallen. Being honest about it, although we weren't getting paid to keep the whole thing together, that ended up part of the role that [AutoEngineer] had to take, unofficially, because [VM] would have kept everything discreet from everybody and only fed out certain information to each person. A programme that is as fragmented as this would have failed if we had not shared information openly – it has got very aggressive timing, very low development costs.* (AutoEngineer Business Unit Director)

Again, this quote illustrated the differences in perceptions surrounding the maintenance and management of confidentiality.

Therefore, several network constraints on communication were evident. Different forms of dependency, notably administrative or logistical, technological and path dependencies significantly inhibited communication. Similarly, the potential risk of loss of knowledge inhibited communication; however, this risk appeared to be effectively managed through supplier segmentation, or different levels of openness, or transparency, within different levels of supplier involvement.

Network as enabler of communicating:

The previous section discussed how the network in several instances acted as a constraint. Conversely, the same network enabled AutoEngineer to access information it would have struggled to identify on its own. For example, AutoEngineer networked with VM's alliance partners without VM's assistance, seeking technical information and solutions.

AutoEngineer also encouraged communication between the two prototype suppliers, wanting them to work closely together on the project. However, they were not in a position to do so with the production suppliers. Overall, there were few examples of the use of the network to enable communication.

Exchanging human resources

There appeared to be a high degree of exchange of human resources in the case study of AutoEngineer. In the relationship between AutoEngineer and VM, as discussed in previous sections, a VM vehicle integration manager was placed on site within AutoEngineer. He served as a focal point for communication of design ideas and concepts. Furthermore, Eltra allocated a resident engineer to AutoEngineer, and AutoEngineer effectively allocated a team of ten engineers to VM, who frequently travelled between the UK and VM's Asian office.[108] According to VM, AutoEngineer had initially resisted having to allocate resident engineers to the customer.

[108] Intriguingly, the team comprised ten people according to AutoEngineer but only four-five people according to VM.

The two prototype suppliers were very closely involved in the project and on site approximately two days a week but not as actual guest engineers on an exchange basis. However, AutoEngineer had its own engineering office with engineers based at both prototype suppliers to 'review progress and assist' with any problems, according to AutoEngineer, and to 'learn' about the manufacturing process, according to one of the prototype suppliers. Hence, there were somewhat different perceptions as to the purpose and benefactor of this arrangement. This level of exchange was apparently more extensive than on other AutoEngineer projects and seemed to reflect a new way of working for AutoEngineer.

In the relationships amongst AutoEngineer and the Asian production suppliers, AutoEngineer's staff paid frequent visits but were not allocated on any longer term basis. The Business Unit Director believed that this was not critical due to the relative simplicity of the engineering task for production suppliers. There was, however, evidence of what could be characterised as 'human resource exchange' in these relationships the other way around. Several of the Asian production suppliers had allocated staff for up to two months for the purpose of training at AutoEngineer's premises.

Finally, two designers from ADC worked at AutoEngineer for six months to understand the design processes. This was seen as important as ADC had to assume the control of design and engineering following the end of AutoEngineer's involvement in the project.

Network as constraint on human resource exchange

There appeared to be few constraining network effects on the process of exchanging human resources within the key relationships. AutoEngineer had limited experience of allocating residents to projects, in fact, VM emphasised that it was not least AutoEngineer's lack of experience in Asia which required it to allocate people. Hence, path dependency in terms of the lack of experience of AutoEngineer in similar projects appeared to influence AutoEngineer's willingness to allocate residents to projects.

Despite the high degree of confidentiality in the project, the inter-connected customer-supplier relationships did not cause any major concerns amongst the respondents. The AutoEngineer Technical Manager explained that only essential project personnel were able to enter the project areas:

> *In some cases it meant that various of their suppliers would have to work with them on site so there would have to be a certain amount of relocation of manpower to ensure that everything worked smoothly. At various periods of time people from both companies would be required to work in different organisations so they had a certain confidentiality to work with.... We set it up so that both companies had secure, cordoned-off, project-dedicated working areas with signing in and restricted keypad access.........They were doing work for other people as well and just like we don't like going round to customers and seeing other people's work there, because it shows a lack of confidentiality. Wherever we go we expect to see things covered up or behind closed doors and our project was not different.* (AutoEngineer Technical Manager)

Thus, managing the potential risk of loss of technological and design knowledge was seen as a core part of AutoEngineer's business process, which earned it its reputation as a trusted engineering partner for vehicle manufacturers. This enabled AutoEngineer to engage in human resource exchange without impairing confidentiality.

Network as enabler of human resource exchange

The network enabled human resource exchange in the project as this activity took place across two radically different parts of the networks, or 'supply chains'. In other words, the Asian production suppliers allocated teams not only to AutoEngineer but also to the prototype suppliers. The indirect competition to win the volume production business between the prototype suppliers and some of the Asian manufacturers, did not seem to prevent exchange of staff across the two chains.

In addition, the network enabled human resource exchange in the sense that two engineers from the prototype suppliers' suppliers had been on site at AutoEngineer's premises to offer their assistance. However, the extent of this activity appeared to be limited.

Synchronising

Synchronising in the project primarily related to the development of the overall project plan. VM and AutoEngineer mutually discussed and agreed the project plan (with input from the prototype suppliers). It was difficult to establish the extent to which the production suppliers had been involved in synchronisation. However, the AutoEngineer Business Unit Director expressed some dissatisfaction with VM's reluctance to share the project timing with the production suppliers, apparently because of confidentiality concerns (see next section). VM's reluctance was not confirmed or reflected in the VM interview, however. The VM respondent revealed that he had deliberately only specified an overall level of timings and processes, leaving some degree of flexibility and choice with individual suppliers rather than dictating this from VM. Thus, there seemed to be some disagreement as to the best way to manage project synchronisation and some uncertainty regarding whether production suppliers were part of the planning.

There was apparently limited consideration of alignment of future technological development beyond the scope of individual projects; this included the relationship between VM and AutoEngineer. The only form of alignment between AutoEngineer and vehicle manufacturers related to attempts to liaise with various vehicle manufacturers' R&D departments, although AutoEngineer had recently announced a strategic liaison with another engineering company aiming to develop new technology.

Network as constraint on synchronising:
As described above, there were some perceived problems with synchronising, some of which can be attributed to negative network effects. The first concerns the synchronisation with the production suppliers. This was clearly inhibited by the late involvement of these. As discussed earlier under 'timing', this was a result of the delay in the JV contract. In other words, it was an administrative or logistical dependency, of a legal nature.

Moreover, network dependency was evident in the fact that AutoEngineer had to cope with different customer processes and procedures. Different customers would use different systems and AutoEngineer's strategy for dealing with this potential conflict was to maintain a generic system as far as possible. In fact, AutoEngineer regarded this flexibility as a cornerstone of its organisation, or in other words a core capability. Thus, AutoEngineer intentionally sought to limit this administrative or logistical dependency as it could otherwise make it problematic to synchronise across different customer relationships.

Path dependency did not appear to have any significant constraining effects on the process of synchronising. However, one of the prototype suppliers raised an issue concerning a historical impact. This related to the fact that experience over time with a range of customers was useful to assess the attainability of project timings. Hence, history again functioned as an enabler in this respect rather than a constraint. The AutoEngineer Manufacturing Manager also explained that history had not significantly affected the level or ways of synchronising, partly because the project had so many new elements and relationships. This was reflected in VM's decision not to enforce its existing processes upon AutoEngineer. Thus, path – or past - dependency functioned as an enabler rather than as a constraint on synchronising.

Finally, there was evidence of network constraint in the form of risk of loss of knowledge:

> *[The lack of synchronisation] was one of my bugbears? [VM} would not share the timing of the programme with the production suppliers. Some of the production suppliers to this day do not know when full-scale serial production starts. They have some rough idea when the non-saleable build is and the saleable build. Full-scale supply starts in the first quarter of 2003.... The belief within [VM] in [Asia] is that the [Asians] cannot keep a secret and they will share it with all their competitors.... [VM] is very very anxious that their competitors don't find out about this programme and don't find out about the materials involved.* (AutoEngineer Business Unit Director)

Hence, this problem concerned the perception that VM refused to involve the Asian production suppliers in the synchronisation process due to confidentiality concerns. VM was concerned that the production suppliers would divulge confidential knowledge of the materials to third parties and ultimately to VM's competitors. The risk of loss of knowledge to third parties thus seemed to constitute a negative network effect on synchronising.

Network as enabler of synchronising

Apart from the above-mentioned positive effects of history, or in some respects the lack of it, there were no other positive or enabling network effects on this process.

Problem solving

The process of resolving problems in this case was rather innovative and interesting. The manufacturing manager explained:

> *AutoEngineer has a 'concern system', which is an electronic method of raising any issue on the programme. It is a central database of everything that we have come*

across – whether it's a technical issue or whether it's a business, commercial, logistical issue – anything. AutoEngineer will normally call a meeting of all those with a hand in that issue - suppliers – and the meeting will usually be held at the place the problem has shown itself.

In addition to this system AutoEngineer would hold weekly design reviews. A virtual reality centre, which allowed all CAD data to be projected onto a screen, would further enable the problem solving process. During those sessions people from different functions, such as product engineers, manufacturing engineers or suppliers, would scrutinise the design and seek to identify problems or causes of problems. Individuals would be allocated to resolve the problem and ensure the implementation of appropriate design changes. These individuals would not only be internal, but also external, such as suppliers.

Overall, the focus in the problem solving process seemed to be on joint problem resolution. It could also be described as a process focused on identifying root causes of problems rather than symptoms, although it was acknowledged that this was often easier said than done. The two prototype suppliers and VM also confirmed the mutuality of the process and non-blame strategy.

Network as constraint on problem solving

The importance of history, in terms of lack of different types of experience, had an effect on problem solving, according to some respondents. Firstly, it related to the lack of an existing relationship between VM and AutoEngineer, which meant that there was no mutual understanding between the two parties when the project started. Secondly, it related to the inexperience not least of AutoEngineer of working in Asia, which caused communication problems. Thirdly, the lack of technological history or path in relation to the new material application meant that problems arose because there were so many unknown factors and no existing benchmarks. This made it difficult to identify root causes of problems. Thus, in this instance it was the lack of history and experience, which had a negative impact on the process of problem solving in the project.

One respondent mentioned that many problems occurred as a result of the high frequency of engineering changes in the project. However, this did not appear to affect the *process* of problem resolution. There were also network constraints, which related to disagreements between VM R&D and AutoEngineer concerning the root causes of technical problems. This was because the R&D people apparently had limited interest in production and thus limited practical input into the problem solving process.

The final issue that emerged from the interviews related to the fact that many AutoEngineer employees worked on several different projects with different customers and suppliers. According to one of the prototype suppliers, this made these individuals very difficult to access. This was therefore a problem of administrative or logistical dependency, in terms of managing and balancing the interfaces with different external actors.

Network as enabler of problem solving

There was very little evidence of anything that can be ascribed to positive enabling effects of the network on the process of problem solving. The only example involved the assembly of indirect actors, such as one of the prototype suppliers and VM, with the specific aim to resolve critical problems.

7.2.3. Summary of Network Effects on Collaboration Activities

Table 19 summarises the main network effects on collaboration activities.

Table 19. Main Network Effects on Collaboration Activities

	Network as Constraint	Network as Enabler
Uniting	- Admin./logistical dependency through limited 'consensus-focused' intervention in supplier selection by VM - Some suppliers deliberately avoided due inter-connected customer-supplier relationships and associated fears of risk of loss of knowledge to competitors	- History with prototype suppliers: involved by default to reduce risk. - FC involved through VM subsidiary in Far East (access) - Indirect FC supplier nomination for safety critical parts (agreed with VM). - FC asked prototype suppliers to dual source to limit risk
Timing	- Late involvement of several parties due to JV set up problems, notably production suppliers: admin./logistical (legal) dependency	- Limited attempts by FC/VM to influence timing of sub-supplier involvement
Mobilising	- Frequency of changes in JV set up & ground rules: admin. (legal) dependency + frequent engine (and related) changes: technological dependency: caused frustration/mobilisation problems for FC	- VM encouraged suppliers to ensure clarity of goals
Communicating	- FC experience with other vehicle manufacturers restricted communication with VM (path dependence). - Weak VM alliance relations and JV problems constrained extent of communication: technological and admin. (legal) dependencies. - Confidentiality concerns restricted communication: need-to-know basis (open within select relationships).	- FC encouraged communication between two prototype suppliers - FC networked with VM's alliance partners without VM's assistance, seeking technical information and solutions.
Exchanging human resources	- Few network effects: only FC's lack of experience in HR exchange affected its willingness to allocate residents to project.	- HR exchange across two 'supply chains': prototype and production suppliers - Prototype sub-suppliers offered assistance at FC
Synchronising	- VM unwillingness to synchronise with production suppliers (confidentiality concerns/risk of loss of knowledge) - Delay in JV arrangement caused late synchronisation with production suppliers: admin. (legal) dependency - FC coping with different customer systems: admin./logistical dependency - No effect of history on synchronising	- No significant effects, although history an enabler in judging attainability of project plans e.g. milestones.
Problem solving	- Lack of history/existing relationship between FC and VM: no initial mutual understanding - Lack of technological path complicated root cause analysis - Technological dependency: problems agreeing causes of technical problems with VM R&D - Admin. dependency: balancing different projects	- Few effects: assembly of 'indirect' actors to resolve problems

NB: 'FC': Focal Company/AutoEngineer

Next the findings from the performance assessment part of the interviews are discussed.

7.2.4. Performance Assessment

Respondents were asked to indicate how the collaboration activities affected a) product development cost, b) product development time, c) the eventual cost of the product, and d) the eventual value of the product. As the project had yet to reach completion only the first two, the product development process, could be assessed. The results are shown in Table 20.

Table 20. Overall Assessment of Respondent Perceptions of Collaboration Activity Performance

	Product Development Cost			Product Development Time		
	positive	neutral	negative	positive	neutral	negative
Uniting	3		2	3	2	
Timing	2	2 + 1 n/a		3	1	1
Mobilising	4	1		3	1	1
Communicating	3	1	1	4	1	
Exchanging human resources	3	1 + 1n/a		2	2 + 1 n/a	
Synchronising		4	1	2	2	1
Problem Solving	5			5		

NB: Numbers refer to number of respondents having ticked positive, neutral or negative box.

Again, it must be stressed that this exercise did not attempt to obtain any hard objective performance measures, but merely an indication of the perceptions of the respondents. Bearing this limitation in mind, it is interesting to note that the majority of the respondents were generally positive towards how the different actors involved had managed activities. There were differing perceptions of the effectiveness/efficiency of uniting, although most respondents were positive. The perceptions of timing were generally positive although several respondents believed it had had no impact on either development cost or time. The views of mobilising were generally positive, as were the views of communication and exchange of human resources. The performance of synchronising was slightly less well perceived. In fact, no one believed it had positively affected product development cost. Finally, the process of problem solving was seen as successful. The overall picture was therefore rather positive.

However, when asked to comment on possible ways to improve how the activities were managed in the future, a number of concerns did surface within the two prototype suppliers. These expressed some concerns regarding communication with AutoEngineer due to the frequency of personnel changes within AutoEngineer, and instances of 'crossed lines' as a result of AutoEngineer not having informed VM of issues discussed amongst the suppliers. Thus, this indicated that communication was perhaps less positive than indicated when asked by a researcher to 'tick a box', and a link between communication and people interaction and continuity.

Several respondents expressed the view that the project had presented a major challenge due to the complexity of the project. The complexity was caused not least by the problems of formalising the JV, and the frequency of precarious technological changes such as engine changes. There was therefore some consensus that this had been a very frustrating project at certain stages. Despite this, there were indications that the project had served as a valuable learning experience for AutoEngineer and many of the suppliers involved. It is in this light that the satisfaction with the process of problem solving should be seen. When the frequent problems emerged, all the actors involved pulled their weight and eventually managed to resolve these.

Finally, an attempt has been made to map the level of collaboration amongst the key actors in the case. Figure 24 shows the interpretation of the level of collaboration displayed within the conduct of each activity. As explained in the previous case, this only serves as a crude indication but seeks to highlight some of the perceived levels and variations of collaboration within key relationships. Notably, the ways in which mobilising, communicating, and synchronising were conducted amongst the key actors appeared to be less collaborative than the other activities; this was particularly pronounced between AutoEngineer and the prototype suppliers. The implication of this is that the management of these relationships seemed to be somewhat inconsistent, being of a collaborative nature in some respects but not all.

Figure 24. Extent of Collaboration in Key AutoEngineer Relationships

	Non-Collaborative	Collaborative
Uniting	- Dictation - Formal vendor assessment procedure	- Joint choice - History & trust important
Timing	Involved in detail engineering or later	Involved in idea generation or concept development
Mobilising	- No sharing of development costs - Individual goals	- Sharing of development costs - Shared goals
Communicating	- Non-transparent exchange of information and knowledge - One-way flow	- Transparent exchange of information and knowledge - Two-way flow
Exchanging HR	No allocation of engineers to project	Engineers allocated to project
Synchronising	- Imposed project plan - Isolated technology development	- Agreed project plan - Alignment of technology development
Problem Solving	Blame of other party	Focus on root cause analysis

● AutoEngineer – VM Relationship
⊕ AutoEngineer/VM – Prototype Suppliers Relationships

7.2.5. Conclusions from the Asian Car Development Project Case

The story of the Asian vehicle development project, as seen from the eyes of AutoEngineer, is a compelling account of a highly intricate and ambitious innovation project. Although most of the respondents interviewed indicated that they had found the project very interesting, it clearly had presented a major managerial challenge to all the parties involved. This project represented a case of doing new things in a new way; it involved a technological innovation, an organisational innovation, and a market innovation. Nevertheless, the outcome of the project in terms of the design and construction of the car was very simple; it was driven by low target cost rather than technological sophistication.

All activities were significantly constrained by the network, although human resource exchange appeared to be less affected. One negative, constraining, network effect that was frequently manifested across the activities related to fears of loss of core technological knowledge to competitors. This impacted not least on uniting and communicating, and to some extent also on synchronising. Moreover, there were several types of dependency, which inhibited many activities. These dependencies were administrative or logistical, as a result of the problems of the three JV parties in formalising their contractual agreement (and thus of a legal nature), and technological; they impacted on all activities except human resource exchange. In addition, path dependency, conceptualised as a network constraint, did have some impact on the conduct of certain activities e.g. on communicating. However, the effect of path dependence was predominantly as a network enabler in the form of the positive effect of experience e.g. on uniting. In the cases where there was lack of experience, e.g. with Asian production suppliers, this can be seen as a network constraint. However, it is conceptually problematic to determine whether the lack of a factor qualifies it as a constraint (and conversely as an enabler if existing). This may, however, be an inherent flaw of the IDEF0 model upon which the conceptual model was constructed: enablers and constraints on processes seem to be the flip sides of the same coin. There were no other obvious forms of dependency. These dependencies all meant that AutoEngineer, as the focal company in this case, to some extent lost control over its actions and activities; it was unable to manage the project in the way it would otherwise have done.

However, this could have been even more severe had the customer/vehicle manufacturer intervened more than it did here, for example, in the process of uniting.[109]

The positive, enabling, network effects seemed to relate to significant amounts of *networking*, for example, to access engine technology. This appeared to concern mostly uniting and communicating. There was some evidence of network co-ordination. There were indications that the intervention strategy employed, for example concerning sub-supplier nomination by the focal company, was to keep intervention to a minimum due to the design simplicity and low target cost driving the project. It also seemed likely that the relatively low degree of power of the customer i.e. the JV, prevented it from exerting its power through network co-ordination strategies. There was little evidence of explicit application of network dissemination to delegate responsibility within the network. However, as in the case of the fuel tank project this might indicate an implicit approach to dissemination, or delegation, although this may be a problematic conclusion as no respondents explicitly confirmed this.

The focal company seemed to be relatively influential within the network, not least vis-à-vis its large global customer. Consequently, it was in a position to influence, and intervene, even more than it apparently chose to do in this particular project. AutoEngineer's rationale for the relatively low degree of intervention was the simple nature and low cost target of the product to be developed. A higher level of product specification could therefore have resulted in more elaborate attempts to control activities beyond the dyadic level. The network co-ordination manifested in some activities was to some extent jointly managed and agreed between the vehicle manufacturer and AutoEngineer; this also indicates the collaborative nature of their relationship and undertaking. Whether this represents a shift in - or delegation of - responsibility of management within networks from vehicle manufacturers towards 'first tier suppliers', is one of the questions emerging from this case.

[109] In comparison with, for example, the vehicle manufacturer in the case of the fuel tank development project which will be discussed in more detail in Chapter Eight.

7.3. Base Station Equipment Development Project

7.3.1 Context

The project in this case is called 'RFC' and concerns the development of a new high frequency component, which forms a critical part of the base stations that make up telecommunications networks. The case is seen from the focal perspective of a large electronics company, which is part of a multi-national PLC. The PLC specialises in commercial wireless communication and other electronic solutions. The part of the overall company that forms the focus of this case study will be referred to as 'TelePart'. It was formed only a few decades ago and has grown to be one of the leading suppliers of wireless equipment. TelePart generally operates as a 'first tier' supplier to telecommunications network providers.

The RFC project is described as very different and much more problematic compared to usual projects in which TelePart had been involved. The customer for the product is one of the major global telecommunications OEMs, in this report known as 'TM'. Initially it was TelePart's European division that was involved with TM on the project in response to the original specification that was released by TM's European division. RFC was then transferred to TelePart UK in October 2001, as the European division did not have the required production capability.[110] TelePart UK was to re-design the component, applying the active devices developed by its European division and combining those with a component using the UK technology to provide a product that was more mass producible. The transfer process was not without its problems, however, and resulted in a project management shake-up, including replacement of the project manager. The problems delayed the process by approximately six months and left TM rather dissatisfied. At the time of data collection for the case (summer 2002) RFC was in the final prototyping stage.

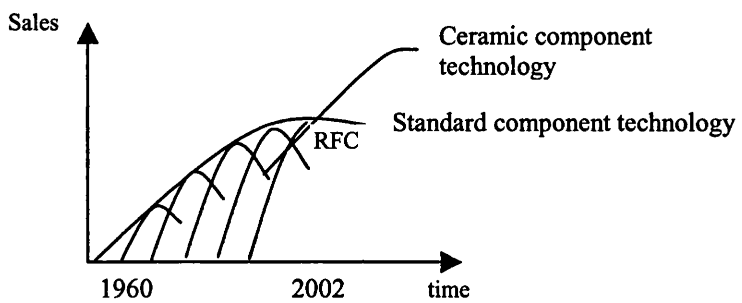
The degree of innovation in RFC is incremental rather than radical. There are no new technologies applied in the project, although some new components are used e.g. amplifier components and transistors that are new to TelePart. It has therefore taken no

[110] The European production technology would have been difficult to replicate in other sites e.g. Far East.

steps to protect technology applied in the project. As such, RFC can perhaps be described as new product introduction rather than new product development or innovation. Hence, it is a fairly low risk project. Interestingly this is not least so because parts of TM prefer that any new product apply tried and tested technologies.[111] The RFC project has therefore not been chosen for this case study due to its level of innovation but primarily because it is a recent project which presented a number of management problems to TelePart.

TelePart applies a number of core technologies in its products, one of which is a standard technique that has been used in the component industry for 40 to 50 years. New emerging technologies are ceramic single, dual and multi-mode, some of which are ready to enter production but have yet to progress beyond pilot/test stage. Figure 25 illustrates that RFC is the latest product application using the standard technology, and that ceramic technology, one of the emerging technologies, is predicted to take over in the near future.

Figure 25: Product and Technology Life Cycles in TelePart



More innovation is to be found in the base station unit of which RFC forms a part, as base stations have to be developed in line with 3G requirements. However, the type of innovation is very different from the mobile phone market, as the following quote illustrates:

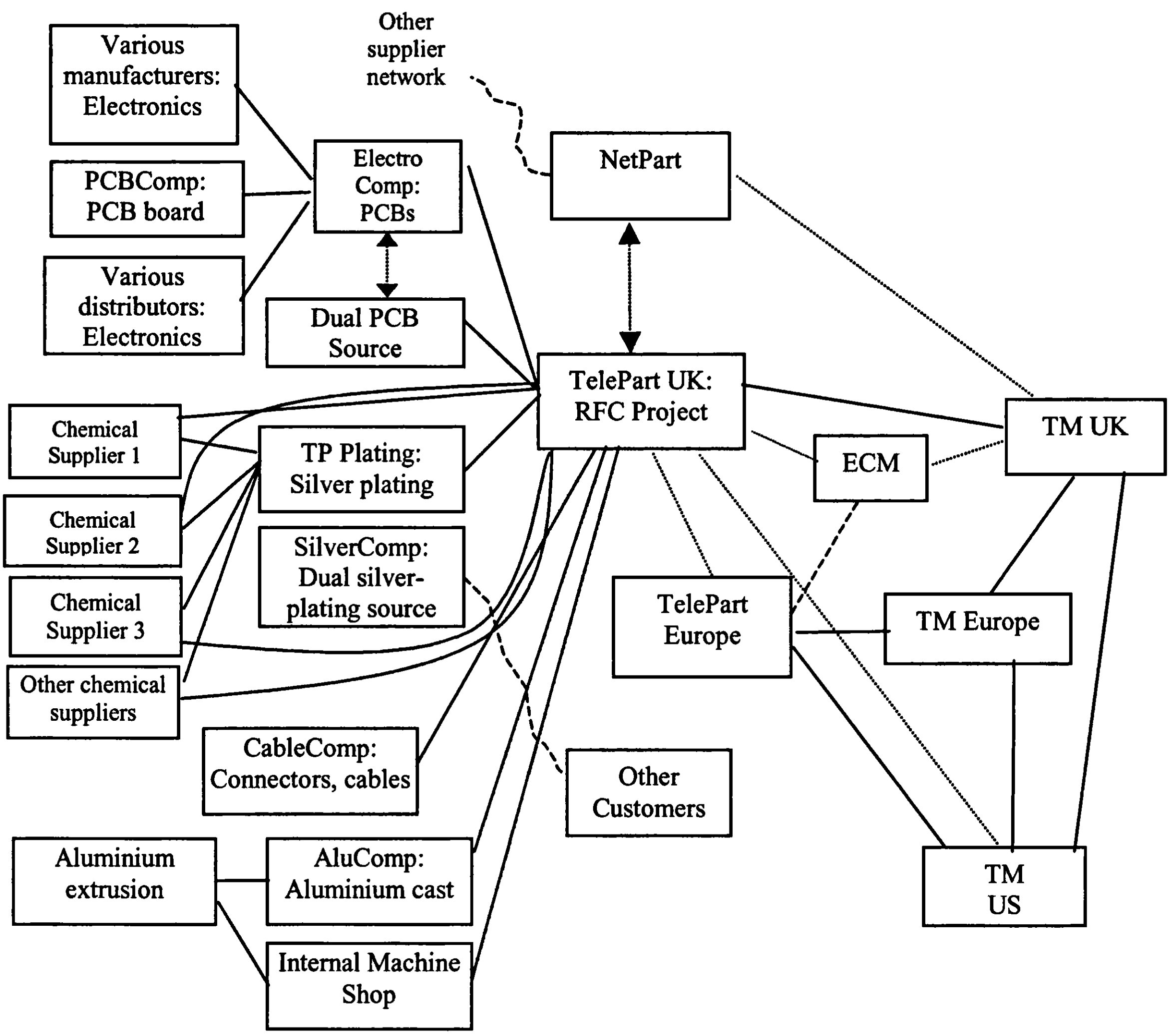
> *With the handset its like let's get innovation out there, let's ... make it a desirable piece of kit. With the network side of it it's how can we de-risk it and reduce the costs. But*

[111] TM R&D advocate new innovation but TM Purchasing and Product Engineering prefer the safe and tested option. There is therefore a (perceived) division of preference within TM.

you know, I am not going to sell more base stations by having more bells and whistles. On the base station, if I make it smaller or make it lighter, or make it lower cost or more reliable then those are the much more technological, more technical type of drivers rather than you know its got an LCD display that is in full colour or whatever, it doesn't matter on the base station (TelePart Sales Manager)

The structure of the network is illustrated in Figure 26. Some components are included, although actual names of companies are disguised to retain confidentiality. The map identifies the main actors involved and their contribution to the project e.g. part developed/ to be supplied. TelePart's supplier network is 'non-delegated' in the sense that it has made no attempts to delegate sub-system assembly roles to suppliers.[112]

Figure 26: Base Station Equipment Development Project: Network Map



[112] There is currently a more delegated structure in TelePart's Asia-Pacific division. In comparison the UK strategy is to maintain more control in-house.

The map is drawn with TelePart as the focal company thus in the centre of the network. TelePart is the single source with TM for RFC, although TM usually dual source. At the time of interviewing it was still being considered whether to dual source to reduce the risk; this second source is the actor 'NetPart.[113] The relationship began in the mid-1990s and became much more intense in 1997/98 when TM began to source at a larger global scale from TelePart. There is mutual dependency in the relationship, as TelePart currently achieves approximately 70 per cent of TM's business and 60–70 per cent of TelePart's business is with TM. TelePart perceives that it is a strategic supplier to TM, yet the TM respondent revealed that TM classifies TelePart as a 'strategic sub-contractor' but not as a 'strategic partner' (although possibly on its way to becoming a 'strategic partner').[114] This difference is significant as TM partnerships are governed by frame agreements and share in TM's risks and rewards. Partners are also always single source and have closer involvement in NPD. Moreover, they share in strategic road maps and have early design phase involvement, including participation in conceptual feasibility work. This is to be examined in more depth under 'Collaboration Activities'. Part of the reason for not being a partner is that TelePart's technology is not seen as TM core technology; it is considered lower risk and hence there is less need for strategic supplier involvement. However, it also emerged from the TM interview that TelePart had simply not performed well enough to assume the 'partner' status; in other words TM did not have sufficient competence trust in TelePart.

The relationship between 'ECM' and TM is an increasingly common form of relationship. ECM performs a manufacturing function, which TM used to retain in-house. As part of an out-sourcing initiative this capability was sold but then brought in as a sub-contractor in the RFC project to assist with purchasing and sourcing as TM realised that it no longer possessed these capabilities in-house.

AluComp is a medium-sized company that specialises in high pressure and precision die-casting and makes component bodies for TelePart. It is perceived as a supplier of critical parts by TelePart and thus has some design involvement. 55 per cent of AluComp's business is with the automotive industry, the remaining activity is with the

[113] There is a TelePart perception that TM is reluctant for either one of the dual sources to become too innovative as it would make transfer from one source to the other more problematic i.e. increase dependency.
[114] TelePart also supply other products to TM, including some which apply an evolving disruptive technology, thus putting TelePart in a more competitive position.

electronics, telecoms and construction industries. In fact, TelePart only accounts for approximately three per cent of its turnover. In other words, its dependency on TelePart is very low.

ElectroComp is a small telecoms contract manufacturer, which is highly dependent on TelePart business as 70-80 per cent of its business is with TelePart. It is perceived by TelePart as being slightly less critical than AluComp and therefore has less design involvement. Although due to its prototyping capability it does perform some prototyping work, unlike AluComp whose prototyping capability is seen by TelePart as minimal. The relationship comes with significant history, as TelePart had recruited several people from ElectroComp, including TelePart's Managing Director. Furthermore, strong family ties exist at high levels.

TP Plating is a profit centre based within TelePart. It employs just under 60 people. It produces and supplies the silver-plating, however, TelePart purchases materials on its behalf, and hence TP Plating has little impact on its supplier relationships. TP Plating only works for TelePart, although TelePart has an external dual source for production back-up.

As will become apparent from the next section discussing collaboration activities between the actors of this case, TelePart sees little need for involving suppliers in product development, however, the Programme Director explained that suppliers do have a significant role in technology development e.g. ceramic technology development. These suppliers may become involved in production later but have to compete on an even basis with other suppliers.

The activities that took place during the course of the project as part of the management of the relationships shown in Figure 26 are to be discussed in the following section.

7.3.2. Collaboration Activities

This section reports the findings on the set of collaboration activities. The findings from each activity are reported one-by-one. This describes the nature of each activity with regard to different actors and examines the evidence of how the network in a variety of ways both enabled and constrained the conduct of each activity.

Uniting

For the purpose of this research project the uniting of actors for the RFC project mainly related to the TelePart – TM relationship, and the uniting of TelePart and its suppliers.

The uniting of TelePart and TM appeared on the surface to be a standard request for quotation and proposal process; however, the process was complicated by a number of factors. The first of these concerned the internal site co-ordination as the original specification/proposal took place between the European divisions of TelePart and TM. After initial prototyping the project was transferred to TM UK and consequently to TelePart UK; this was because it would allow the project to be managed within the same country and because TelePart's UK manufacturing technology was easier to replicate across global sites. ECM assisted TM in its sourcing decision, due to its experience in the field.

TelePart's process of involving suppliers was described as a three-part approval process, depending on the level of importance. However, interviews with TelePart suppliers revealed a delay in TelePart's feedback to the suppliers, leaving these unaware of whether or not they had won the business.

Network as constraint on uniting

The analysis of uniting across internal and external interviews showed that there were several constraints on the process, which could be attributed to network effects.

One form of negative network effect related to different forms of dependency. This was firstly in the form of network co-ordination employed by TM, intervening in TelePart's supplier selection process through indirect supplier nomination. TM specified parts but not actual suppliers, although this still resulted in a list of approved suppliers.

The list of approved suppliers would typically consist of established suppliers which had shown credibility through past performance and where mutual understanding of needs and requirements had evolved. This thus constituted a path dependency effect. The importance and manifestation of this effect could also be seen by the fact that the adoption of new suppliers on the list was seen by some respondents as costly and difficult as these had to undergo an extensive qualification process.

Furthermore, the network inhibited the process of uniting as the list of approved suppliers would exclude these suppliers which had failed to respect confidentiality, leaking confidential customer information to competitors; alternatively they would be classified as 'non-preferred'. Uniting was thus not only a matter of performance but also a question of understanding network connections. The interview with ElectroComp indicated the significance of this effect and the inter-relatedness of different forms of dependency:

> *We have offered alternative manufacturers for the approval process, some which would alleviate the single-source scenario...., which could potentially offer a cost saving on the parts. So far we have not succeeded in introducing [other suppliers]. [Our suppliers] are specified by TelePart – some components are specified through TM as in the electronic devices.... There has been a lot of negotiation between TelePart and TM to get this [approved parts] list together. If there is any deviation from that parts list then it would need to go back through the re-approval process, which costs thousands of pounds and time of the engineers. So once we have produced this product and it has been approved by TelePart and TM with the range of components then that is set in stone and we can't deviate from that particular range of components. There is a fixed number of alternative manufacturers that TelePart and TM would accept.*

Whereas this indicated an administrative or logistical dependency effect, it also reflected a path dependency effect as it shows how a complex procedure of selecting suppliers is unlikely to be repeated and thus effectively restricting new suppliers becoming part of the network.

Network as enabler of uniting

Whilst the network evidently constrained the process of uniting in several significant ways it also enabled the process. That was the situation, for example, when TelePart consulted TM about its assessment of a potential supplier. It also occurred through its own nomination of indirect suppliers, although this was limited; most supplier (or part) specification was conducted by TM albeit in conjunction with TelePart. Apart from these examples of intervention there was no other evidence of network co-ordination.

Timing

TelePart's initiation into the project with TM occurred during initial prototyping when a request for quotation and a specification were released, that is, relatively late.

However, TelePart Europe had been involved earlier for pre-specification and thus able to influence the design specification. In addition, TelePart interacted on a continuous basis with TM for long- and medium-term technology development beyond individual projects.

The general pattern of timing within this case study, however, was one of relatively late supplier involvement, which many respondents perceived to cause considerable design and manufacturing problems. Almost all suppliers expressed a desire to become involved in the process to better influence design specifications and ensure better design for manufacture. The fundamental problem of the RFC project according to most respondents had been the number of design changes, which most suppliers interviewed agreed could be improved through their earlier involvement and input into specifications. One of TelePart's suppliers explained the significance of this lateness:

> *A simple example on the production shop floor is some of the units in manufacture: The easiest thing to manufacture is a square board.... If the boards we buy are designed to be square or rectangle, we can minimise wastage. We are also able to panellise the subs so we can get multiple boards on one panel so it reduces our handling time and our process time and maximises the throughput of the machine. [However] some of the designs have the most fantastic shapes you've ever seen – curves, small hands hanging off them, rocket-shaped boards, strange sizes... TelePart's designers must be looking at the size of the base station they need and how the electronics are going to fit... We don't know, we're guessing. We get, "This is what we want you to make."*

This quote illustrates how a manufacturing problem may well occur if suppliers are not involved in the design specification process.

Network as constraint and enabler on timing:
There were very few real network effects on the timing of actor involvement. The only effects related to experience of involving suppliers early on in projects. This was, according to one supplier, a likely reason why it had not been implemented to date. The history of collaboration between TelePart Europe and TM Europe also seemed to be a key factor in early involvement of TelePart Europe. TelePart Europe used to be part of

TM Europe; hence the personal bonds were very strong.[115] Thus, the lack of experience of early supplier involvement appeared to constitute a constraint and *vice versa*. There was no evidence of any attempts to influence the timing of any indirect suppliers; this was a decision left to direct suppliers to handle.

Mobilising

The division of development costs amongst most actors in this case was primarily conducted on the basis of suppliers having to recover investments once products had been launched, whether consciously or unconsciously having to manage a balanced product portfolio, ensuring that some generate sufficient funds for technological innovation. The TM respondent revealed, however, that it had 'frame agreements' with its partners, which ensured that these received a relatively high margin to cover a proportion of its development costs and provide long-term security. Given TelePart's categorisation as in the grey area between 'partner' and 'strategic sub-contractor', it apparently enjoyed a good margin, albeit not as good as a TM partner. This will be discussed further in the next section.

TelePart had few long-term agreements with any of its suppliers. At most, expensive tooling costs were covered (some jointly with TM), or in the case of one of the suppliers interviewed, a prototype agreement existed which specified support for development work. Suppliers generally felt that risk and benefit sharing was very one-sided. In addition, one recent change of TelePart policy regarding automatic charge for reject parts had caused much controversy within its suppliers.

Despite the high volume and value of TM's business there was a perception of frequent motivation problems amongst both internal and external respondents. Within TelePart this problem seemed to concern engineering staff rather than management and appeared to be related to the amount of pressure arising from tight project deadlines, project clashes etc. However, TelePart's own approach to mobilising its suppliers was described as a 'bully' approach, using an 'exit' strategy if suppliers failed to perform or conform. This adversarial tactic was seen as very de-motivating to the concerned suppliers as they perceived this as reflecting a lack of respect for the supplier. There also appeared to be a related issue concerning the lack of future business security.

[115] In addition to a strong cultural bond, as TelePart Europe and TM Europe originate from the same country.

TelePart's suppliers commonly spoke of the lack of visibility and clear ground rules, which was a particular concern for highly dependent suppliers (see next section).

Network as constraint on mobilising:
The history between the actors involved in the project was generally regarded as a positive influence on motivation, hence enabler rather than constraint. However, the high degree of what can perhaps best be described as 'commercial dependency' of one of the suppliers interviewed constrained mobilisation, because it did not always feel it had the extent of visibility and future business security to warrant such a high level of dependency. The conceptual issue of this form of dependency effect will be discussed later. Another supplier interviewed stated that for this reason it had a policy of not being over-reliant on any one customer. TM also explained this rationale in relation to its relationship with TelePart:

> *...because they are sub contractor we are quite happy that they have got other relationships because we don't want to have all their work because ..... one of the reasons you go to a sub contractor is that you know you have got the flexibility when times are hard...... the worst that can happen is if they are doing like ninety percent [TM] business it means that we have got zero flexibility, if we stop a contract or we lose an order or something they are going to be out of business for three months which means they are probably gonna go, not bust, but they are going to have real major problems. We would rather they only had about a third of our business so that we have got plenty of scope for movement up and down and that's what we prefer as a strategy. It is a little bit different for partners because we have got a frame agreement - there you have got some kind of project, a place to support each other.* (TM)

Thus, TM clearly had a strategy of avoiding its 'strategic sub-contractors' being over-dependent on TM business. As the next quote illustrates this differentiation also impacted on the extent of risk and reward sharing between TM and TelePart:

> *....we don't use the word 'partner' with [TelePart], they are a 'strategic sub contractor'.... at [TM] we are quite strong on that differentiation.... A partner is someone who is actually sharing with us in terms of risk and reward so they really are very close to [TM] ....[TelePart] are more 'sub contractors' so it's a little bit one step removed.* (TM)

Finally, one supplier expressed a concern that TelePart's problems were 'snowballed' to its suppliers, as it had to put pressure on them when TelePart was putting it under pressure.

Hence, there were significant positive path dependency effects on the process of mobilising, as well as what may be interpreted as a form of dependency that did not appear to be included in the conceptual structure; this could possibly best be described as 'commercial' dependency. This is discussed in more detail later.

Network as enabler of mobilising:
There was some evidence of the network enabling the mobilisation of suppliers. TelePart tried to influence the mobilising of sub-suppliers e.g. by directly driving delivery targets. Sometimes this would be conducted in conjunction with TM. Furthermore, TelePart intervened in an indirect supplier relationship by negotiating costs and margins and thence 'free-issuing' parts.

The dual sourcing strategies of TelePart and TM also served as a motivator as better performing suppliers gained a higher proportion of the business.

Therefore, there were several cases of the network functioning as an enabler of mobilising.

Communicating
There appeared to be extensive communication amongst the key actors in the project. Such communication concerned, for example, specifications, policies, procedures, and cost information, and to a lesser degree, performance information. TelePart had conducted a supplier satisfaction survey, obtaining feedback on its supplier relationships. This had indicated a number of communication problems, particularly lack of consistent communication. As an outcome of the survey a supplier newsletter had been discussed but not implemented. In general, much communication was formalised through, for example, meeting minutes, but there was also evidence of wide informal communication through e.g. email and telephone.

Despite the apparently large quantity of communication, there was a wide perception of a communications problem within TelePart, thus impacting on the quality of its external communication.[116] This was most strongly identified by TM, which expressed disappointment regarding the extent to which it felt it needed to drag information out of TelePart. This concerned not only information on project problems and delays, often not communicated not to lose face, but also design. TM felt it had to specify too many details to TelePart and would have preferred if TelePart had been able to manage the design itself with less input from TM, or in other words a black box approach.[117] In fact, TM expressed a concern that TelePart withheld too much information. The communication problem was also recognised within the supplier relationships as these all, save the internal supplier, had very strong views regarding the lack of visibility of TelePart's products (e.g. forecasts) and decisions.

It was clear that although TelePart claimed to perceive some of its suppliers to be more important than others, there was little real differentiation in terms of communication patterns: no one supplier received markedly more information than other suppliers. TelePart's suppliers, however, generally believed that they were more open not only with TelePart but also their own suppliers.[118]

Network as constraint on communicating

It follows from the previous section that communication in this case was not entirely transparent and that some information was indeed withheld. One of the TelePart respondents explained that this had partly been a personnel issue, as the initial Programme Manager, who had been replaced, had withheld much information, however, this had changed to some extent with the new Programme Manager. The approach to communication, however, was often described as 'a need to know basis'. This was evidently the case with TelePart's communication both with TM and suppliers; the rationale for this was a concern for loss of valuable knowledge to third parties. Consequently, there was a very strong culture of confidentiality within TelePart. This also affected its suppliers, for example one supplier was not allowed to use any product information from its involvement with TelePart for its promotion with other customers. These limitations on communication thus indicated a network effect in terms of risks of loss of valuable knowledge.

[116] Only the TelePart Programme Director thought the problem was exaggerated.
[117] The communication problem was recognised by TelePart to the extent that it was involved in another academic project concerning communication at the same time as the present study took place.
[118] As these were not interviewed it is difficult to verify these assertions.

There was evidence also of path dependency effects on communication patterns. Again, path dependency had a dual effect. On the one hand, it meant that TM suppliers, which had failed to respect confidentiality and used sensitive information to their own advantage with TM's competitors, were now classified as 'non-preferred' (see also previous section on uniting). On the other hand, as one of the TelePart respondents explained, historical suppliers would be likely to receive more informal information compared with new suppliers.

Network as enabler of communicating:
There were some attempts to use the network to co-ordinate communication. This was the case, for example, when TelePart in conjunction with TM conducted supplier development activity to share ideas and knowledge. TelePart saw this as a very useful activity. It was also the case when TelePart, somewhat to the surprise of one supplier, asked two suppliers to collaborate:

> *[Dual PCB Source] was a bit taken aback by the way [TelePart] expects people to work together. There was a UPS shipment from one of our suppliers in Germany that got lost and so we contacted [TelePart] and asked them whether the other subcontract manufacturer – [Dual PCB Source] – had any stock available. We both contacted [Dual PCB Source] to see if we could get any parts to keep us running. They found it strange to be selling parts to their competitor – although we had both been contracted to have 50% of the business each supplying [TM} through [TelePart].* (ElectroComp)

There were no other examples of any attempts to use the network to enable communication. The supplier newsletter mentioned in the previous section would have been an example of this, but it failed to materialise.

Exchanging human resources
There was no evidence of any human resource exchange in terms of actual secondment of staff to other companies. The common response amongst TelePart's suppliers was that this had never been requested. In one supplier's case, however, this was seen as less relevant than other means of interacting, due to its locality, and thus not a consequence of the network. In the case of the internal supplier, this was clearly a strong feature of its relationship with TelePart due to its adjacent premises; hence human interaction was very strong.

Network as enabler and constraint on exchanging human resources:
TelePart used to exchange staff with TM in previous projects and indeed TM stated that it did have engineers of its partners working alongside its own engineers in-house. Whether or not the network had any impact on this apparent lack of exchange of staff is difficult to infer. The TelePart Programme Director stated that confidentiality concerns could have played a part in this, although it could also be because there was a perception that it would not positively influence productivity.

Hence, the network may have prevented human resource exchange from taking place due to confidentiality concerns. However, there seemed to be other non-network related explanatory factors preventing this activity.

Synchronising
Synchronisation in this project related first of all to project planning. This seemed largely to revolve around development of Gantt charts by TelePart and TM. The perceptions of whether or not suppliers had any visibility of, or involvement in, development and sharing of project plans varied. The TelePart project manager stated that project plans were synchronised with suppliers. In contrast, judging from the majority of the interviews, including interviews with the suppliers in question, the view of the project manager appeared to be somewhat invalid. According to the two external suppliers they had surprisingly little visibility of any project plans. One of the external suppliers saw the exchange of project plans purely as a one-way street: it knew that TelePart produced its own project plan but had no visibility of this. The other external supplier interviewed expressed its frustration with this situation:

> *We just fulfil orders. There is project management within [TelePart] but we are not aware of timing or volumes or mix, goals, milestones...... We don't know when it's going to kick in. We have not seen [project details] appear on any forecast information so far. We don't know what capacity would be required to fulfil the orders. We don't know what additional tooling would be required, what additional processes needed... We are pretty much in the dark and just waiting for [TelePart's] lead at the moment. Originally I heard on the grapevine that it was partly for [one OEM]. I don't think that's the case now because I spoke to one of the engineers when we were building the first boards and he said it was for [TM].* (ElectroComp)

Clearly, the lack of synchronisation with certain suppliers related to the late and low involvement of these. It seemed that TelePart did not see the need for synchronising with any suppliers, preferring instead the flexibility of being able to switch supplier until the last possible phase of the project.

The second form of synchronisation related to the long-term strategic alignment of key actors involved in the project. It was clear from interviews with TelePart that it made a significant effort to communicate and share its technology road maps and quality development plans with TM.

The form of sharing of technology road maps was not entirely mutual. TM only revealed its technology road maps with 'key partners' and given TelePart's status it appeared from the TM interview that such partners were given more detailed information than TelePart. For example, TM did not share any details of its product strategy with TelePart.[119] One TelePart respondent stated that although many individuals within TelePart had some ideas of the technological direction of TM, these perceptions varied widely. Unsurprisingly, TelePart's suppliers had no visibility of any road maps.

Network as constraint on synchronising:
The inter-connectedness of network relationships evidently constrained the sharing and adaptation of technology road maps. As described in the previous section, TelePart revealed all its road maps to TM and was keen to ensure that TM knew about its technological direction. TM, however, was less transparent about its technology plans. According to the TM respondent it was concerned that TelePart had relationships with TM competitors, which restricted its ability to become a 'partner' and thus share in TM's technology strategy. There was a TM preference for a maximum of 30-50 per cent of TM dependency for 'strategic sub-contractors', but a higher degree of dependency would be allowed for 'partners' because frame agreements, including arrangements for mutual support, were in place to prevent problems arising from high dependency.[120]

In the TelePart – supplier relationships the network implications on the limited amount of sharing and synchronising were unclear. There had, apparently, been some past

[119] TM's strategic feedback to TelePart mainly included market trend information.
[120] The rationale for this strategy was illustrated in the TM quote under the earlier 'mobilising' discussion.

concerns about a group of suppliers being used by too many telecommunications companies. This implied that there had been confidentiality concerns. Path dependency was only evident from the views of one TelePart respondent who believed that most synchronisations were in place from previous projects i.e. a positive effect, although judging from the majority of the interviews, it was doubtful whether there was any real synchronisation.

Network as enabler of synchronising

There appeared to be no positive network effects on synchronising in this case. The only issue, which was raised by one supplier, related to its alignment of its systems and procedures with its customers. These were aligned with general industry requirements rather than any one customer.

Problem solving

The RFC project had been troubled by numerous problems throughout the process. Many of these related to re-design and specification problems. Other problems related to perceived communication, project management, and risk management problems (the latter mostly TM's concern).

The process for resolving problems was often described as fairly unstructured brainstorming sessions. The process generally focused on identifying root causes, however, two of TelePart's suppliers stated that TelePart was quick to jump to the conclusion that they problem lay within the supplier's internal processes. Problem resolution was also often woven into supplier development activity.

Network as constraint on problem solving

Only one of the external actor interviewees revealed any network constraints on the process of problem solving. This was a path dependency effect manifested in an ingrained behaviour:

> *....Our past history would have had an impact on people's "This is the way it has always been done" attitude – it's difficult to change people's perceptions and procedures as well as the processes, their ideas of how it should be done......* TP Plating

Hence, this apparent reluctance to resolve problems by changing processes, which had evolved over time, provides a good example of a negative network effect.

Although one internal TelePart respondent did not indicate any path dependency effects on problem solving, another (the Group Quality Manager) believed that history did have an influence. This was because TM had developed over time a perception of TelePart being very reactive in its problem solving process, relying to a large extent on TM to take action. This respondent also highlighted that some of its other customers had expressed concerns about TelePart being too dependent on TM and thus not receiving the same amount of attention, not least when problems had to be resolved. This therefore indicated a perceived administrative or logistical dependency problem, specifically of a commercial nature.

Network as enabler of problem solving

There was only one case of any positive enabling effects of the network on problem solving. This was raised by the TelePart Group Quality Engineer who pointed out that sub-suppliers had been involved in solving complex problems. No other respondents identified any relevance of positive network effects on the problem solving process.

7.3.3. Summary of Network Effect on Collaboration Activities

Table 21 summarises the main network effects on collaboration activities.

Table 21. Main Network Effects on Collaboration Activities

	Network as Constraint	Network as Enablers
Uniting	• Admin. dependency: indirect sub-supplier nomination through TM parts approval list • Path dependency: established suppliers on approval list– costly qualification process to add new suppliers to list. Approval list excluded TM suppliers failing to respect confidentiality	• Indirect (parts) specification by TP in conjunction with TM • TP consulted TM re. its assessment of TP suppliers
Timing	• Path dependency: lack of experience of early supplier involvement prevents practice	• Close historical link between TM Europe and TP Europe enabled early involvement (positive path dependency)
Mobilising	• Admin./logistical (commercial) dependency: TM frame agreements with highly dependent suppliers • TP problems transfer across relationships and cause chain of mobilisation problems	• Path dependency: enabling supplier motivation • TP dual sourcing mobilised supplier performance • TP negotiating with indirect suppliers • TP drove sub-supplier delivery targets in conjunction with TM
Communicating	• Information re. project problems withheld from TM: TP confidentiality culture • Path dependency: suppliers failing to respect confidentiality non-preferred	• Path dependency: historical suppliers receive more information • Two TP suppliers asked to communicate to resolve delivery problem
Exchanging Human Resources	• Possibly no HR exchange due to confidentiality concerns	• No examples/cases
Synchronising	• TM reluctant to share road maps with TP: partly due to TP having other customer relationships: admin. dependency	• Only example related to synchronisations being in place from previous projects (positive path dependency)
Problem Solving	• Path dependency: people being change averse • Perceived admin./logistical (commercial) dependency problem: TP being over-dependent on TM	• Few effects: involvement of TP sub-supplier in resolving complex problems

TP: TelePart

The following section discusses the findings from the performance assessment part of the interviews.

7.3.4. Performance Assessment

Respondents were asked to indicate how they perceived the way in which the collaboration activities were actually carried out in this project, affected a) product development cost, b) product development time, c) the eventual cost of the product, and d) the eventual value of the product. The results are shown in Table 22.

Table 22. Overall Assessment of Respondent Perceptions of Collaboration Activity Performance

	Product development Cost			Product development Time			Eventual Product Cost			Eventual Product Value		
	+	+/-	-	+	+/-	-	+	+/-	-	+	+/-	-
Uniting	2	1	1	3	1		3		1	3		1
Timing	1	2	3	1	2	3	1	1	3	1	1	3
Mobilising		3	3		2	4		2	3	2		3
Communicating		3	3		1	5	1	2	2	1	2	2
Exchanging human resources[121]			3	1		3		1	2		1	2
Synchronising	5	1	2	3	1	2	2		3	2		3
Problem Solving	1		4	2		3		3	1		2	2

NB: Numbers refer to number of respondents having ticked positive, neutral or negative box. The sum of these vary as some respondents did not fill in their assessment of all activities

Bearing the limitation in mind, as discussed in the previous two cases, it is interesting to note that there was a tendency for the majority of respondents to be negative towards how several collaboration activities had been managed in the project. This negativity was not least evident from the external actor interviews, but also internal respondents expressed dissatisfaction with how the collaboration activities had been managed. Bearing the previous analysis in mind it should come as no surprise that timing was perceived by several, but not all, as having had a negative impact on several performance factors. Mobilising likewise was seen as negative. The most negative single effect, however, was the perceived effect of communication on product development time: there was a perception that the project could have been completed in shorter time had communication been better. Although human resource exchange was limited, and thus assessed as N/A by some respondents, the lack of this activity was seen by several respondents as having had a negative effect not least on the product development process. In contrast, most respondents, not least on product development cost, viewed synchronising as positive. This was somewhat surprising given the discussions of synchronising, but may indicate that it had not been as poorly performed compared with other activities. Finally, the majority of respondents perceived problem solving as having had a negative effect on product development cost.

[121] Some respondents regarded this activity as Not Applicable

The rather subjective performance assessment in Table 22 was to some extent confirmed by TelePart in its own analysis of some performance factors. It had identified a gap between unit target cost and the actual cost. TelePart perceived this to be a result of TM's frequent change of product specifications. It was widely acknowledged that the project performance had not been good, but that it had been a good learning experience for some individual members of staff.

Finally, an attempt has been made to map the level of collaboration amongst the key actors in the case. Figure 27 shows the interpretation of the level of collaboration displayed through the conduct of each activity. Whereas this can only serve as a crude indication it highlights some of the perceived levels and variations of collaboration within key relationships.

Notably, TelePart's relationships with its suppliers, as reflected in the collaboration activities, appeared to be very non-collaborative. In fact, TelePart believed that it did not need close collaboration with its suppliers. For example, the Programme Director stated that most TelePart suppliers were seen as pure sourcing relationships. Nevertheless, the performance assessment indicated there was a range of perceived negative effects partly because of the lack of supplier involvement. The extent of collaboration in TelePart's relationship with TM was much more collaborative, although as TelePart was not classified as a 'partner' by TM the degree of collaboration could have been stronger.

Figure 27. Extent of Collaboration in Key TelePart Relationships

	Non-Collaborative	**Collaborative**
Uniting	- Dictation - Formal vendor assessment procedure	- Joint choice - History & trust important
Timing	Involved in detail engineering or later	Involved in idea generation or concept development
Mobilising	- Non-sharing of development costs - Individual goals	- Sharing of development costs - Shared goals
Communicating	- Non-transparent exchange of information and knowledge - One-way flow	- Transparent exchange of information and knowledge - Two-way flow
Exchanging HR	No allocation of engineers to project	Engineers allocated to project
Synchronising	- Imposed project plan - Isolated technology development	- Agreed project plan - Alignment of technology development
Problem Solving	Blame of other party	Focus on root cause analysis

TelePart – TM Relationship
TelePart – Supplier Relationships

7.3.5. Conclusions from Base Station Equipment Project Case

The base station equipment development case is a story of a highly problematic product development, or introduction, project. The degree of innovation in the project was incremental rather than radical, building on established technology. Likewise it emerged from the findings that the level of collaboration between TelePart and its suppliers was rather low, to the extent that the focal firm, TelePart, generally perceived its supplier relationships as pure sourcing relationships. The relationship between TelePart and the key customer in this case, TM, was much closer, although not quite as close as some other TM supplier relationships. This had important implications for the extent to which TelePart was allowed to become highly involved with, and dependent on, TM. Importantly, the TM respondent revealed that its 'partnerships' were governed by frame agreements and share in TM's risks and rewards and these were always single source and had closer involvement in new product development. Furthermore, they shared in strategic road maps and had early design phase involvement, including participation in conceptual feasibility work. TelePart was apparently classified in the grey area between 'partner' and 'strategic sub-contractor, enjoying some of the benefits of 'partners' but not all. TelePart's actions indicated that it was seeking to gain the role of 'partner', however, this was a road paved with difficulty due not least to patterns of behaviour, which had been in place for a long period of time. Such patterns included poor project management performance and thus had left TM with a lack of confidence or trust in TelePart's competence in managing complex innovation projects.

The limited degree of supplier involvement in the project appeared to be a central factor in explaining the multitude of problems encountered during the process. Key factors in particular seemed to be the late involvement of suppliers and the opaque nature of communication, or the lack of it. However, the low extent of supplier collaboration was reflected across all the activities examined. Hence, the collaboration activities could hardly be interpreted as true 'collaboration'.

Most collaboration activities were significantly constrained by the network in which the actors and their actions were enmeshed. One negative network effect, the fear of loss of core knowledge to competitors, inhibited several activities, including uniting, communicating, synchronising, and possibly human resource exchange. Path dependency in the form of historical relationship decisions and actions, also had a negative influence on the way activities were conducted, including uniting, timing, communicating, and problem solving. Finally, other forms of dependency, such as administrative, logistical, and what may be emerging as a new form of sub-form of administrative or logistical dependency, 'commercial' dependency, constrained uniting, mobilising, synchronising, and problem solving. This was not included in the conceptual structure, but can perhaps be seen as equivalent to what Cousins classifies as 'economic dependency' (2002).

The collaboration activities were not only constrained by the network, but also enabled. As in the other case studies path dependency did not merely have a negative constraining effect on activities, causing inertia in the change process. Several activities were enabled by path dependency in terms of mutual experience being developed over time and thus allowed close relationships to evolve. Timing, mobilising, communicating, and synchronising were all positively influenced by history. Other forms of network enabling effects included examples of network co-ordination, such as when two suppliers were asked to liaise and communicate with each other. However, such examples were relatively rare as were examples of use of access strategies. TM did, often in conjunction with TelePart, specify indirect parts and compiled approved supplier lists, but as this was not direct sub-supplier nomination this did not constitute a strong case of network intervention in the process of supplier selection or *uniting*. Such intervention was also rare across other activities, although there were some examples in problem solving and mobilising. TM was clearly a very powerful actor in this network, however, its approach to managing its supplier relationships seemed to be to rely on its suppliers to manage their own relationships rather than exerting its power through intervention.

7.4. The Interception Gateway Development Project

7.4.1. Context

The present case concerns a project that is driven by the legal need to provide an interception gateway to national law enforcement agencies thus enabling these to wiretap mobility networks. The product to be developed will interface with network switches to draw data from these. This project aims to evolve the existing second-generation (2G) technology into third generation (3G) compliance. The main difference in this evolution is the change from voice to data transmission; hence the purpose of this project is to enable the interception of data transfer on mobility networks, for example, mobile phone text and picture messaging and email.[122]

The case is seen from the perspective of a mobility networks supplier and is predominantly dyadic in nature as it involves mainly two actors: NetCom, the chosen focal company and the owner of the intellectual property rights of the finalised product, and Securicom Systems, the system supplier.[123] NetCom is a major Western global competitor. In this market NetCom operates as an OEM whose normal customers are the mobility networks providers. However, in this particular case the customers are the law enforcement agencies, which fulfil a legal security role rather than a commercial role. NetCom and Securicom must ensure compliance with a number of standards and regulations, including most importantly CALEA[124] (Communications Assistance to Law Enforcement Act), and ETSI (European Telecommunication Standards Institute for law enforcement agencies). This implies that although Securicom's aim is to profit from the project, the aim of NetCom is to comply with the regulation in order to remain within the terms and conditions of the license, rather than making a profit or achieving any

[122] The International Telecommunication Union definition of 3G technology stipulates that it must be capable of supporting data transmission speeds of at least 144 kilobits per second outdoors and two megabits per second inside buildings. One of its key visions is to provide seamless global 'roaming', enabling users to move across borders while using the same number and handset (http://www.itu.int)

[123] As the network map in Figure 27 indicates, many other actors were involved, however, only two actors could be accessed.

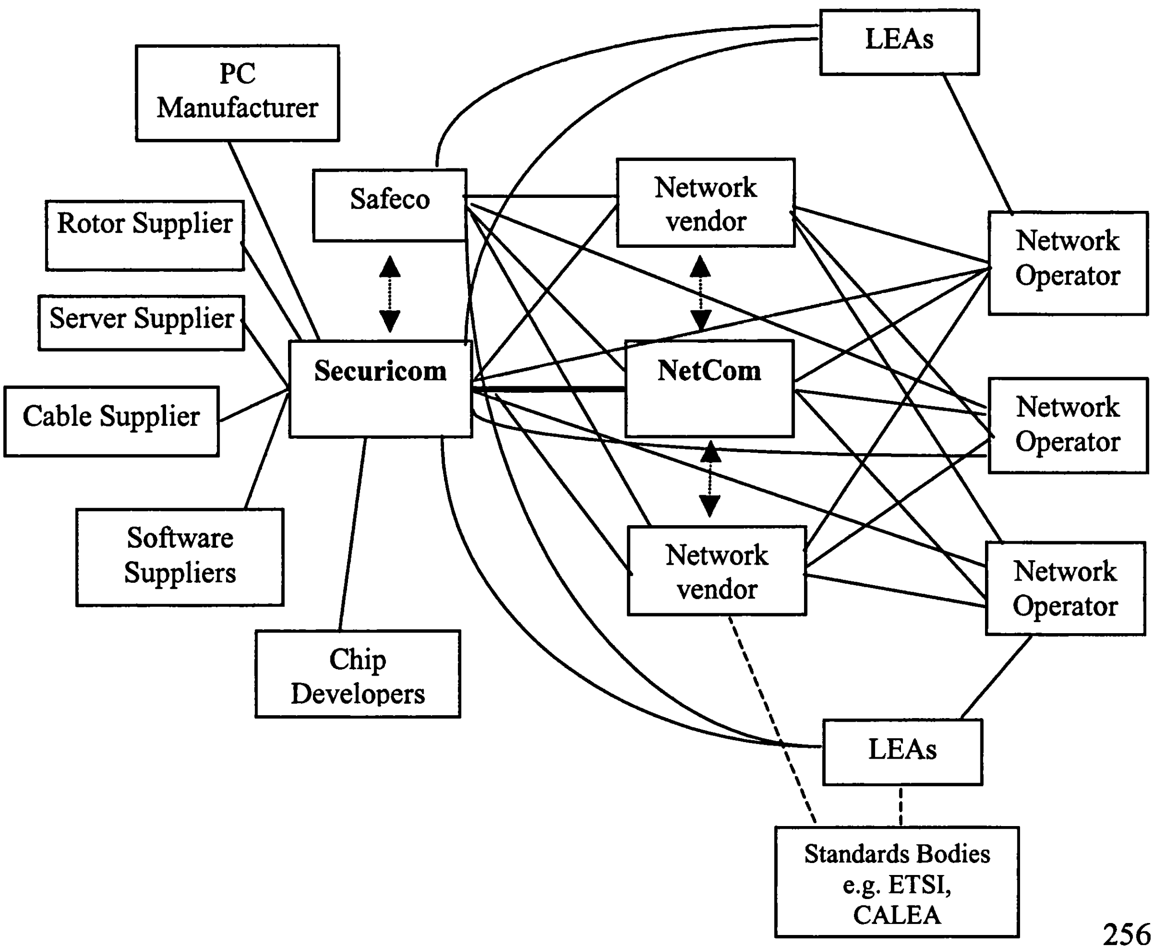
[124] A 1994 law granting law enforcement agencies the ability to wiretap new digital networks and requiring wireless and wire line carriers to enable eavesdropping equipment use in digital networks (http://www.itu.int).

competitive advantage. At the time of writing the project was undergoing final testing, approximately eighteen months after its initiation.

The present project is part of a rapid development of telecommunications mobility technology from 2G to 3G, and the innovation challenge is complex as it is part of the major systemic shift from (2G) voice to (3G) data transmission. The recent delay in realising true 3G standards on a global scale has revealed the magnitude of this technological innovation. The project in focus is thus not developed from scratch but is based on a re-development of the 2G technology; this is primarily a change in software rather than hardware. Thus, the innovation is driven by a set of well-defined, albeit complex, evolving international technology standards; these may be interpreted as the current technological paradigm.

The structure of the network is illustrated in Figure 28. Actual names of actors have been disguised to retain confidentiality. The map identifies the main actors involved and their contribution to the project e.g. part developed/to be supplied.

Figure 28: Interception Gateway Development Project: Network Map



The supplier of the eavesdropping equipment is Securicom Systems. It has a division in the Middle East, which is the focal sales and marketing point in this project. It is an international company with a global presence and one of two key players in the market. One of its major products is branded Apollo, which is an integrated hardware/software solution. This product, and the future 3G version being developed with NetCom, must be compliant with the network switches of all the main players in the market, although each may require its own degree of customisation. It must also meet the multitude of international standards and regulations. Hence Securicom has relationships not only with network vendors, such as NetCom, but also with the law enforcement agencies across the world. NetCom considers its relationship with Securicom to be important and is looking to develop it into a more strategic relationship. Securicom's suppliers include major PC and other hardware suppliers, however, given the large software nature of the technology there are few 'component' suppliers, and indeed these are not seen as critical.[125] Safeco is the other major player in the market and used by NetCom in other regions of the world. The end customers are the law enforcement agencies, shown to the right of the network map. These also liaise closely with the network operators as it is within their systems that the eavesdropping equipment needs to be placed.

The activities that took place during the course of the project as part of the management of the relationships shown in Figure 28 are to be discussed in the following section.

7.4.2. Collaboration activities

This section reports the findings on the set of collaboration activities. The findings from each activity are reported one-by-one. The nature of each activity with regard to different actors is described and the evidence of how the network in a variety of ways both enabled and constrained the conduct of each activity is examined.

Uniting

In this case study the process concentrates mainly on the uniting of two actors: NetCom and Securicom. The process of how NetCom's sub-suppliers became involved is considered in the subsequent sections as part of network effects.

[125] The Securicom respondent nevertheless considered most of its suppliers confidential and was reluctant to reveal any detailed information about these.

NetCom initially underwent internal discussions whether to develop the technology in-house, however, having decided to sub-contract the work, an invitation to tender was sent out to two potential suppliers. Thus the process was on one level a standard tendering process although, as will be discussed in the following section, Securicom clearly had 'a foot in the door' given its existing status as supplier for 2G-based technology. NetCom also had limited choice given the niche character of the market and the strict conditions regarding compliance with a number of 3G requirements. Given Securicom's active attempt to become selected the process can be seen as interactive.

Network as constraint on uniting

The analysis reveals a clear path dependency effect on NetCom's decision to involve Securicom. This is illustrated in the following quote:

> *NetCom and Securicom have a history of collaboration in respect of the second generation i.e. GSM network offer and thus in the first instance it was deemed appropriate that we would continue that collaboration by extending the second generation product relationship to become the third generation. Now having said all of that as well in order to validate that view we entered into a competitive tender albeit with two suppliers in January 2001.... Securicom was selected predominately on two grounds: The first being [that] their existing ... product brought with it a high degree of technical compliance with our own technical requirements document and in the second instance the pricing provided by Securicom was far more favourable.....* (NetCom Supply Chain Manager)

This quote shows how there may be positive path dependency effects on the process of uniting, but that in itself past involvement was insufficient to ensure that Securicom re-won the business, as its offer still had to be competitive. Interestingly, NetCom's Project Manager stated that Securicom's prior involvement actually worked against it becoming re-involved due to its unsatisfactory past performance. Thus, the past may work in favour or against a supplier's re-selection depending on the customer perception of the quality of past performance.

A further network constraining effect on uniting was the need for Securicom's technology to be compliant and compatible with a number of vendor switches:

The Securicom product is very much based around compliance with a large number of vendor switches..... Securicom will sell to vendors such as NetCom .... or at other times Securicom will sell into the operators themselves....They will have to ensure that they have a [product] which is capable of interfacing with each of those networks.... So we are aware of that but clearly we have to take the view that Securicom are a professional organisation who will honour our confidentiality just in the same way they will honour our competitor's confidentiality. That's the reality of doing business in this place. (NetCom Supply Chain Manager)

As the quote indicates the potential breach of confidentiality, due to different customer relationships, is regarded as a necessary albeit tolerable risk. It also illustrates how uniting was influenced by wider network concerns given the systemic nature of the technology and the innovation.

Network as enabler of uniting

Unlike the other cases there were no real attempts to influence sub-supplier selection, neither through direct nomination nor through sub-supplier approval. NetCom viewed the choice of its sub-suppliers to be the sole responsibility of Securicom. The factors that appeared to govern this were the lack of influence in this particular market as well as the large element of software in the technology, which would limit the opportunities for NetCom to conduct, for example, value engineering. In addition to this the complex integral product architecture also appeared to restrict NetCom's ability to influence sub-supplier selection:

You know where we buy products in bulk lets say, where our relationship is stronger where our spend is higher, where our influence is greater yes then we will aim to secure a kind of leverage over the supplier. We would aim to influence the parts list lets say the choice of components to the extent that we might specify them or jointly develop the parts list with the vendor......

Securicom expanded on this:

I can go to the market and buy all kinds of screw and as long as they have a certain thread.... ok any screw is the same. What I am talking about, software, every software is different, I need software developers that know this kind of software, now if I change database I need other kind of products I don't have, I need to change it that's very

> *expensive for me. If NetCom is going to say don't use this database use that then I am going to say 'ok but then you need to pay me at least ten years experience of people for training them in the new database or to retrain programmers or to hire in programmers that's very expensive'.* (Securicom)

Hence from Securicom's perspective any intervention by NetCom in its supplier relationships would be very problematic, as it would have systems-wide implications. It appeared that it was at least partly due to the high software proportion of the suppliers that it would not merely be a matter of switching from one supplier to another; any switch of supplier would affect the rest of Securicom's system. By implication this indicated that it was the non-modular or integral product and technology architecture, which rendered sub-supplier nomination impracticable. Hence the structure of the supply network was not easily inter-changeable.

Timing

Securicom became involved in the project immediately following NetCom's internally developed product specification. This meant that Securicom had no input into the specification, which the NetCom Supply Chain Manager in hindsight believed had had a negative effect on the overall product development time as time was wasted with Securicom having to make adjustments to the NetCom specification. He believed that the main reason why it had decided to produce the specification in-house was simply that NetCom had a culture of producing specifications in-house, viewing this as part of its own core competence. This is therefore ultimately a network, or networking, problem.

Network as constraint and enabler on timing:

The following quote illustrates the dilemma NetCom faced regarding whether or not to allow Securicom, or any other qualified supplier, to control the product specification process and thus become involved earlier in development projects:

> *NetCom... have some very adept personnel who can produce highly complex, highly detailed, highly accurate technical specifications but that doesn't mean that we are the experts in the field of lawful intercept. Securicom are the experts in that field they have relationships at a vendor level i.e. the like of NetCom, they have relationships at an operator level they have relationships with the law enforcement agency level and the standards body level. I mean they are the people who are the real experts in this. We*

should take advantage of that and we should take benefit from that.......the reason why they weren't involved to the extent that I have just outlined is cultural frankly in that NetCom has a culture of building products in house, specifying products in house, developing products in house and whilst that model is shifting to more of an emphasis on third party ownership of those activities as NetCom downsizes and as NetCom comes to grip with a smaller organisation..... the corporate mind set in end of 2000 beginning of 2001 when we undertook this exercise was very much along 'well we'll design it we'll take the lead and the third party can follow our lead'....... Well why should we spend time money and effort on work which we are not really qualified to do when there is another party or parties who are eminently qualified to do that...... unfortunately these things aren't forced upon you I guess until the resource is less readily available.

The realisation that Securicom could - or in NetCom's view *should* – have been involved earlier to produce the specification, happened to coincide with a process of downsizing. Whereas such a process might force NetCom to reconsider its own core technological competencies and technologies vis-à-vis other network actors, or the make-or-buy decision, the quote also questioned the underlying general principle of customer-controlled specifications. Therefore, this was a form of technological dependency effect.

No attempts by NetCom to influence the timing of sub-suppliers were unveiled. As discussed under 'uniting' the management of these relationships in terms of timing was left to Securicom.

Mobilising

Financially, the project was controlled by a formal contract that established costs, terms and conditions, including ground rules, responsibilities etc.. The NetCom Project Manager stated that whereas it had not been a problem to induce Securicom to commit to the project, meeting the commitments or deadlines was a different issue. In fact, in their totality the interviews exposed the contentious nature of this issue, which was the subject of much debate, thus revealing an atmosphere of discontent and friction in the NetCom-Securicom relationship.

Network as constraint on mobilising:
The problems of Securicom's willingness or ability to fully commit to the project in terms of meeting the milestones as set out in the overall project plan, could partly be attributed to network effects:

> *Well an example of that was I mean the project itself was split into three phases. The initial view on phase three was that that would be deliverable in May of 2002. When it came to April 2002 Securicom announced to us that they wouldn't be able to complete it until August of 2002. The reason being they said was that they felt they had underestimated the main resource needed for that work. Therefore the work would take longer than originally anticipated. The problem for us was that didn't sit within our overall release programme so to that extent we had to enter into vigorous discussions with Securicom and suitable escalation to bring it back on track. That coincidentally was at a time where Securicom and NetCom were bidding for other customer work and a strong suspicion was that the work required for other customers was taking precedence over ours.* (NetCom Supply Chain Manager)

The quote indicates that the problem, as perceived by NetCom, was that of different and shifting customer priorities. Securicom denied any such customer priority, however, NetCom was convinced that this was the cause of problem. The situation was likely exacerbated by the fact that NetCom was a relatively small customer of Securicom and therefore was not in a position of power and influence over its supplier. NetCom had a perception of receiving little attention and limited resource allocation from Securicom at a crucial stage of the project. Such inter-dependency between different customer relationships therefore indicated a negative network effect in the form of a administrative/logistical dependency in the form of the limited commercial or economic dependence of Securicom on NetCom.

Network as enabler of mobilising:
None of the respondents indicated any attempts to enable the process of mobilising by means of the network; again the management of NetCom's sub-supplier relationships in terms of mobilising was delegated to Securicom.

Communicating
The communication between Securicom and NetCom was partly handled through formal documentation and oral presentations and partly through frequent emailing, conference calls and so on. One of the constraints on, for example, face-to-face

communication in this case was the geographical distance between Securicom and NetCom. However, of more importance seemed to be the cultural differences and the mutual lack of understanding that resulted from this, particularly in relation to openness and speed of response:

> *For example somebody from NetCom sent me an e-mail.... after a week he goes mad.... he says ok why didn't you answer the e-mail? I don't know what he is yelling about I don't understand it, [because] it is going to take me two or three weeks [to come up with an answer], a month I don't know whatever and you are going to receive an answer [sooner or later].* (Securicom)

This quote again portrays the sense of frustration and lack of understanding that dominated the atmosphere in the relationship, apparently a result of cultural differences in communication behaviour.

Network as constraint on communicating

The risk of leakage of knowledge was not seen as a problem by any of the respondents. The presence of non-disclosure agreements and the trust that underpinned these, were regarded as sufficient guards against any such problems. The risk was also regarded as minimal due to the tacit nature of the knowledge involved and hence the problems of replicating it to own advantage in other relationships. In other words, it was not a concern because even if a third party obtained any knowledge, it would be unable to do anything with it, as it did not have the experience and ingrained knowledge to put it into its context and make it explicit. Perhaps the fact that this case concerned communication interception and security technology was an additional explanatory factor in the strong culture of respecting confidentiality, a explanation supported by the relative unwillingness of the Securicom respondent to reveal issues of a sensitive nature.

Network as enabler of communicating:

None of the respondents indicated any attempts to enable the process of communicating by means of the network; again the management of NetCom's sub-supplier relationships in terms of communication was left to Securicom.

Exchanging human resources

The NetCom respondents stated that there had been several Securicom engineers at NetCom's sites during installation and testing, albeit less frequent and for shorter weekly duration compared with other NetCom projects. It was explained by the NetCom Project Manager as being due to the relatively small amount of development work required, although the Supply Chain Manager provided a more likely explanation:

> *Quite simply... in the overall scheme of things this ...... probably isn't regarded as one of the key development programmes within NetCom. It's one of those things that's needed and it's one of those things that gets a lot of attention if it goes wrong but it's not because it's not a revenue earner because it's a legal necessity rather than a revenue earner it's not always given significant attention.*

This quote seems to be a likely explanation of the lack of this activity in this project.

Network as enabler and constraint on exchanging human resources:
It follows from the explanation in the previous section that the lack of commercial incentive within NetCom influenced its decision not to seek more human resource exchange. It appeared to be this consideration rather than any network effects, which governed this process, although the presence of NDAs (Non Disclosure Agreements) and mutual trust ensured that the extent of human resource exchange that did take place, was not regarded as entailing any risk of breach of confidentiality.

Synchronising
The project seemed to be well synchronised through exchange of project plans, mainly Gantt charts. From a long-term perspective there were two emerging issues. The first pertained to the specific strategic alignment between Securicom and NetCom, where once more there were concerns on NetCom's behalf:

> *Certainly the aim of this exercise was to ... align our road map with Securicom's. To align Securicom's road map with ours and if you like to plug any gaps by [appropriate] development. Having said that you know my aim would be to remain conversant with Securicom's road maps such as it might be. I do have a problem therein that Securicom inform me that they don't really have a road map. I find that difficult to believe. I know to an extent the development of their product will be driven by customer standards needs which aren't always easily anticipated but I have to say I do have a certain amount of frustration in it, they don't feel able to give me a forward view on their product planning.* (NetCom Supply Chain Manager)

This quote provides another illustrates the frustration of lack of mutual understanding that seemed to characterise the relationship between the two main actors. The second issue concerned the alignment of strategies at the network level. This is therefore discussed in the following section.

Network as constraint on synchronising:

The alignment of strategies at the network level related to the importance of aligning with the general technological trajectory and regulation within the industry. Most importantly, both NetCom and Securicom saw compliance with 3G as pivotal. The complex yet specific guidelines for 3G technology made it critical that any new technology and any new product be compliant with the regulatory standards as set out by e.g. CALEA and ETSI. This was evidently a strong technological network dependency effect, as any new product or technology, which was non-compliant, could mean that the 3G license would be lost.

At a more immediate network level the problem of the lack of road map exchange was at least partly explained by Securicom in terms of the problem of synchronising development plans and technology road maps with different customers as these often have conflicting directions. The Securicom respondent explained how he was often struggling within his own company to obtain strategic attention:

> *I go to my management [and] I scream that I want NetCom first priority and somebody else goes 'no my customer is first, my customer has priority' so we fight and eventually the senior decided ok this is the first priority for me it's the second and so on* (Securicom)

Ultimately, however, the importance of 3G compliance and the ability to interface Securicom's technology with any customer technology appeared to override the significance of any dyadic alignment. Synchronising at the wider network level seemed to be paramount due to the systemic nature of the technological innovation.

Network as enabler of synchronising

None of the respondents indicated any attempts to enable the process of synchronising by means of the network. Again the management of NetCom's sub-supplier relationships in terms of synchronising was, at least implicitly, delegated to Securicom.

Problem solving

The main problems related to Securicom's problems in meeting milestones and product functionality. The NetCom respondents stated that escalation was required in a few instances but eventual agreements were reached. The process was described as focused on identifying root causes rather than apportioning blame. However, the NetCom Supply Chain Manager believed that Securicom had been somewhat unwilling to recognise the existence of any problems, perhaps hiding the fact that a problem existed in the hope that it would be able to resolve the problem internally. The Supply Chain Manager offered an explanation for this behaviour:

> *I still suspect that the main problem could be that at times they aren't as open with us as they could be and that you know that may well be a cultural thing, either related to their locality or within their organisation. I have said to them I always want to know of problems ideally before they exist and we conduct regular reviews you know to try and ensure that that the case so that we are in a proactive position. Nevertheless from time to time we came to surprises.* (NetCom Supply Chain Manager)

His quote indicated that a cultural difference was the reason for the different approach to problem solving. Overall, it seemed that this cultural difference also contributed to an atmosphere of conflict and friction.

Network as constraint and enabler on problem solving

None of the respondents indicated any attempts to enable the process of problem solving by means of the network. As in several other activities the management of NetCom's sub-supplier relationships in terms of problem solving was implicitly delegated to Securicom.

7.4.3. Summary of Network Effect on Collaboration Activities

Table 23 summarises the main network effects on collaboration activities.

Table 23. Main Network Effects on Collaboration Activities

	Network as Constraint	Network as Enabler
Uniting	• Path dependency: 2G collaboration history partly constrained FC's choice of Securicom	• Path dependency: 2G collaboration history partly enabled FC's choice of Securicom • No attempt by FC to specify sub-suppliers
Timing	• Technological dependency: FC produced specification in-house due to internal competence (afterwards recognised supplier's technical specification competence is stronger)	• No attempt by FC to influence timing of sub-suppliers
Mobilising	• Logistical/admin. dependency: Securicom struggling to commit resources due to other customers (commercial dependency)	• No examples/cases
Communicating	• No confidentiality concerns: managed through NDAs and trust.	• No examples/cases
Exchanging Human Resources	• No confidentiality concerns: managed through NDAs and trust.	• No examples/cases
Synchronising	• Securicom reluctant to share road maps with NetCom: possibly due to different customer requirements: admin. dependency • Technological dependency: need to comply with technological trajectory set by 3G standards.	• No examples/cases
Problem Solving	• No examples/cases	• No examples/cases

FC: NetCom

The following section discusses the findings from the performance assessment part of the interviews.

7.4.4. Performance Assessment

Respondents were asked to indicate how they perceived the way in which the collaboration activities were actually carried out in this project, affected a) product development cost, b) product development time, c) the eventual cost of the product, and d) the eventual value of the product. In this case this exercise had been problematic. Firstly, it was not possible to collect any reliable assessment from the supplier, as the respondent provided only rudimentary responses to most issues and preferred not to provide an answer to others. Secondly, the interview with the NetCom Project Manager had been conducted via telephone; hence a simplified version of the usual procedure was applied. Thus the only data that could be collected were from the two NetCom respondents. The results are shown in Table 24.

Table 24. Overall Assessment of Respondent Perceptions of Collaboration Activity Performance

	Project Performance		
	+	+/-	-
Uniting	2		
Timing	1		1
Mobilising	2		
Communicating			2
Exchanging human resources	1		1
Synchronising*			1
Problem Solving	2		

NB: Numbers refer to number of respondents having ticked positive, neutral or negative box. The sum of these varies, as some respondents did not fill in their assessment of all activities.
* One of the NetCom respondents thought the effects of this process could only be measured long-term

In addition to the limitations of this exercise explained in the other cases, the assessments provided in Table 24 rely merely on the subjective perceptions of only two respondents, who both provided the NetCom perspective. The strongest indication was that communication was seen as having had a negative influence on project performance. As Securicom implied that it was aware of communication problems this assessment seemed to be fair. The opinions regarding the activities of uniting, mobilising, and problem solving were positive, whereas the views of the performance implications of the remaining activities were divided. However, there seemed to be no doubt that Securicom's failure to meet deadlines and milestones had caused a project launch delay.

Finally, Figure 29 shows the interpretation of the level of collaboration displayed through the conduct of each activity, highlighting the perceived level and variation of collaboration.

Figure 29. Extent of Collaboration in Key NetCom Relationships

	Non-Collaborative	Collaborative
Uniting	- Dictation - Formal vendor assessment procedure	- Joint choice - History & trust important
Timing	Involved in detail engineering or later	Involved in idea generation or concept development
Mobilising	- No sharing of development costs - Individual goals	- Sharing of development costs - Shared goals
Communicating	- Non-transparent exchange of information and knowledge - One-way flow	- Transparent exchange of information and knowledge - Two-way flow
Exchanging HR	No allocation of engineers to project	Engineers allocated to project
Synchronising	- Imposed project plan - Isolated technology development	- Agreed project plan - Alignment of technology development
Problem Solving	Blame of other party	Focus on root cause analysis

● Netcom – Securicom Relationship

7.4.5. Conclusions from the Interception Gateway Project Case

The story of the lawful intercept gateway project, as seen from the perspective of NetCom as the focal company, is a case of a project driven by legal compliance rather than commercial ambitions. It was not possible to interview any customer in this case study due to the highly confidential nature of the case, and there was a large reliance on one respondent due to practical limitations. Moreover, due to the idiosyncrasies of the case it focused primarily on the collaboration between NetCom, as the 'project integrator' and Securicom as the key supplier. Indeed, this division of the respective roles of NetCom and Securicom became clear during the course of the data collection process. In hindsight Securicom would possibly have been a more appropriate focal company as it would have been more comparable with the three other case studies. However, practical considerations would have made this impossible, as Securicom was less willing to take part in the research than NetCom. Thus, overall the data collection was restricted in many ways and the relative validity of the case likely to be smaller than the other three cases.

The project concerned the development of a software intensive technology, which formed part of the mobility networks provided by NetCom. The innovation was incremental rather than radical, providing an evolution of previous generation technology. The project was driven by cost rather than technological sophistication, as NetCom did not view it as a core product, which would be able to generate any competitive advantage. This would most likely have been different had Securicom been the focal company.

The idiosyncratic nature of the case appeared to influence the pattern of collaboration activities. Most importantly, NetCom did not seem to be concerned with using the network as an enabler of any activities, although path dependency influenced uniting as an enabler as well as a constraint. Hence there were no attempts by NetCom to specify or in any other ways influence Securicom's supply network. All such decisions seemed to be left in the hands of Securicom thus possibly indicating an implicit approach to dissemination, although as in the other cases this could not be confirmed. It seemed that any intervention by NetCom in Securicom's supplier relationships would have been very problematic, due to the possible systems-wide implications. There were indications that this could partly be explained by the integral and systemic nature of the technology, which meant that suppliers would have been difficult to replace. The case thus raised the question of whether it was the characteristic of the integral, or non-modular, product and technology architecture, which rendered sub-supplier management through an intervention strategy impracticable. NetCom's lack of power and influence over Securicom due to Securicom's low dependency on NetCom's business seemed to be an added factor in understanding this patterns of network behaviour.

There were a number of negative network constraining effects on several activities in the case. Path dependency affected uniting: positively or negatively depending on the perceptions of the respondents. Path dependency seemed to affect no other activity. There also did not seem to be any confidentiality concerns regarding loss of knowledge to any third parties. This was managed through trust and NDAs. Securicom were reluctant to share road maps with NetCom but the network effect on this were uncertain. There were two instances of technological dependency. The first concerned the issue of timing in terms of the perceived need to involve Securicom in the technical specification process. One of the NetCom respondents stated that he believed NetCom should take more advantage of Securicom's technical capabilities in producing specifications; this ultimately seemed to be a question of the level of NetCom competence trust in its supplier. The second concerned synchronising and the need to comply with the wider 3G standards. In other words, NetCom had to ensure that it pursued the technological trajectory as determined by the industry standards bodies. As these standards were set by actors on the periphery of the NetCom network and hence out-with NetCom's control, this presented a real constraint. Finally, there was one case of administrative or logistical dependency on the process of mobilising in terms of Securicom's struggle to commit resources to NetCom due to its relationships with other larger customers. Synchronising was similarly negatively influenced by this form of dependency; it seemed to be of a commercial or economic nature. In summary, the were several network constraints in this case; the most serious of these seemed to relate to the wider network effects related to the problems of legal compliance with the technological standards set by regulatory industrial bodies.

Part Three:
Discussions and Conclusions

Overview of Part Three

Chapter Eight discusses the cross-case comparative analysis of the four case studies. Thereby, conclusions are drawn on the research questions, which were set out at the end of Chapter Four. The analysis builds on the empirical findings and relates these to the literature and, in particular, the conceptual structure. The section concludes by discussing some of the lessons from the case studies, assessing the usefulness and limitations of the conceptual structure.

Chapter Nine presents the overall conclusions from the thesis. Conclusions are drawn upon the aim and objectives that were set out in Chapter One. Then the contribution and limitations of the findings are assessed. This final chapter of the thesis concludes with a discussion of managerial implications.

CHAPTER EIGHT: CROSS CASE COMPARISONS AND THEORETICAL IMPLICATIONS

8.0. Introduction

Chapter Eight discusses the cross-case comparative analysis of the problem areas of the four case studies. Although more specific cross-case analysis was conducted prior to addressing the research questions, the findings are presented here according to, and structured around, the research questions, which were set out at the end of Chapter Four. Appendix G contains the cross-case analysis meta-matrices that were used as the basis for identifying patterns in terms of commonalities and divergences across the individual cases. This is particularly relevant for the discussions of different situations of appropriate network co-ordination strategies and network constraints. The cross-case analysis is therefore mainly the subject of sections 8.5 and 8.6.

The analysis builds on the empirical findings and relates these to the literature reviewed in Chapters Two and Three and, in particular, the conceptual structure. Concepts not considered in the literature review are only introduced when relating to emergent themes that were not identified during the literature review. The section concludes by discussing some of the lessons from the case studies, assessing the usefulness and limitations of the conceptual structure.

8.1. Importance of the 'Access Strategy' in Enabling Collaboration Activities in Product Innovation Projects

The first research question addressed the problem of identifying the relative importance of the access strategy in enabling collaboration activities in the context of product innovation projects. Hence, this question sought to identify whether some activities would draw on the access strategy more than other activities. The access strategy was conceptualised as a way for network actors to gain access to, and exploit, indirect relationships through direct relationships. The access strategy was seen as conceptually close to the concept of 'interaction' although the focus here was on one actor reaching beyond the dyadic relationship through network connections. The case studies sought to capture the use of the access strategy within collaboration activities by identifying ways in which one relationship had been used to gain access to another.

The understanding and conceptualisation of the access strategy evolved during the literature review and the empirical data collection. For example, the exploratory survey included several examples of actors using network connections extensively to gain access to the resources and technologies of other actors. Such examples were also identified in the in-depth cases. However, the cases demonstrated that the concept of the access strategy was problematic to pin down and characterise as a 'strategy'. It seemed to simply describe a basic characteristic of networks and indeed the network function (Håkansson and Snehota, 1995). For example, whenever a company connected with a direct supplier it effectively made use of that supplier to access all of that supplier's relationships. Similarly, a supplier connected with a direct customer to access indirect customers and eventually end customers. Nevertheless, this phenomenon did not appear to relate to all collaboration activities. In fact, the case studies seemed to indicate that companies mainly made use of the access strategy in two collaboration activities; these were uniting and communicating. Within these activities, the case studies revealed a number of interesting practices. Despite the conceptual limitations of the 'access strategy', which are expanded on in section 9.3, some of these practices were interpreted as denoting the access strategy. These are therefore discussed in the following.

The use of the access strategy to *unite* with dispersed network actors seemed to be the *modus operandi* in most cases. In the fuel tank development project, the dedicated role of one supplier was specifically to serve as a gateway to other suppliers, which were geographically and culturally distant, being located in Japan. Thus, the presence of a dedicated network role to facilitate the uniting of different network actors seemed to exemplify a network access strategy. In the other automotive case, such use of networks was also evident, although there seemed to be no formalised network roles. The case of the base station equipment project provided another example of the use of networks to enable companies to unite with network actors; the focal company consulted its customer for its assessment of its own existing and potential suppliers. Such practice thus seemed prevalent across the cases.

Another activity in which companies used the access strategy was *communicating*. This was often in the form of using contacts in the network to obtain information that was difficult to obtain by other means. In the two cases of the Asian car development project and the fuel tank development project, the focal companies obtained critical information, for example regarding design changes, through the use of their network connections.

Companies did not appear to use the access strategy to enable the remaining collaboration activities. Therefore, it can be concluded that of the seven collaboration activities examined in the four case studies, companies only appeared to use the access strategy to enable uniting and communicating. The remaining activities were conducted and managed within dyadic relationships, but individual actors did not seem to take advantage of the access strategy to the same extent to enable those activities.

The findings on the relative significance of network access on uniting and communicating appear to be consistent with other empirical IMP findings. For example, Håkansson and Eriksson (1993) and Wynstra (1999) have indicated the importance of suppliers being well connected for supplier selection (or 'prioritising'). Similarly, the research by Bower (1993) and Bower and Keogh (1997) has shown how a small group of biotechnology and pharmaceutical companies deployed critical resources through networks. The pattern of networking in their accounts is similar to the observations on the use of the access strategy in the case studies in this thesis.

The cases included two particularly interesting examples of what could be classified as a network access strategy. The first example entailed intermediate actors or nodes, e.g. 'direct suppliers', functioning as network access points, or 'conduits' (Easton, 1992), to connect, for example, sub-suppliers and assemblers.[126] In this instance suppliers provided access to the resources or knowledge of sub-suppliers. The direction in such cases was one-way in the sense that the access points connected 'customers' with sub-suppliers through intermediate suppliers. The second example was only observed in one case, namely the base station equipment project. The direction in this case was essentially two-way as it involved an intermediate supplier consulting its customer, for example to gain knowledge about a sub-supplier. The consultation of a customer about a sub-supplier seemed to be facilitated by customers performing structuring or co-ordinating roles.

[126] The notions of direct and indirect actor connections are only meaningful here in so much as they refer to direct or indirect supply relations i.e. in which physical transactions take place. A direct technological relation, for example, may well exist where an otherwise indirect supply relation exists.

The findings concerning specific network roles can be related to the recent work by Harland and Knight (2001) on conceptualising and exploring different 'network management roles'. Building on the work by, amongst others, Snow *et al* (1992), they identified six different roles, including network structuring agent, co-ordinator, advisor, information broker, relationship broker, and innovation sponsor. The findings in this thesis included examples of such relationship and information brokers (in the case of the fuel tank development project), whose roles were to facilitate uniting and communication amongst distant network actors. The supplier known as 'J-Car Commerce' was indeed assigned by the vehicle manufacturer to formally perform such a role, not least by brokering relationships and facilitating communication between the vehicle manufacturer's Japanese suppliers and UK and European suppliers. Hence, the role played by 'J-Car Commerce' was not only to bridge network actors that were geographically distant, but also - and perhaps more importantly - to bridge culturally distant actors. These findings are consistent with those of Harland and Knight (2001) concerning the complexity of such a 'relationship broker' role. The findings indicate the complexity of such a role, for example in the need to facilitate prevention and resolution of (both latent and open) conflict. As Harland and Knight point out (*ibid.*), the relationship broker role thus requires a competent team to smooth out and manage potential sources of conflict. Such conflict includes the risk of loss of valuable knowledge through networks (Ford *et al*, 2003). This is the subject of a separate research question and will therefore be considered later in this chapter.

The findings on network roles are interesting, as they indicate that some network actors actively, and even by means of formal arrangement, try to assign such roles. By implication, such assigning of network roles seems to indicate attempts to co-ordinate networks for improved control of resource and technology access. This indicated a close relationship between network roles and network co-ordination strategies and, therefore, leads to the second research question.

8.2. Application of Network Co-ordination Strategies in Different Collaboration Activities During Product Innovation Projects

The second research question addressed the problem of how a set of network co-ordination strategies may be applied to enable different collaboration activities. Recent literature has discussed how powerful 'hubs' have 'orchestrated' or even 'managed' networks (e.g. Möller and Svahn, 2002; Ritter, 1999; Häcki and Lighton, 2001).[127] The term co-ordination was adopted in this research project, as it does not imply that there is one actor or hub designing and controlling the network in any rational fashion. Co-ordination simply implies attempts to 'manage' in the sense of 'convening' other actors (Lamming *et al*, 2000b; Dyer and Nobeoka, 2000).

Based on the literature review two co-ordination strategies were conceptualised: dissemination and intervention. From the total set of activities the focal firms only appeared to operate network co-ordination strategies to enable two activities; these were uniting and – to a lesser extent - mobilising. However, as discussed later, other network actors (usually assemblers) operated network co-ordination strategies to a higher degree than the focal firms and thus enabled a further collaboration activity, namely communicating. Hence, analysis from different focal points indicates that network co-ordination strategies were employed to enable the activities of communicating, uniting and mobilising.

Firstly, the findings provided clear indications that companies frequently employed network co-ordination strategies to enable *uniting*. The cases provide a multitude of examples of the application of co-ordination strategies in uniting of actors. The most prominent example was of the practice exercised by the focal companies in some of the cases and their customers (generally assemblers) of nominating (and hence uniting with) sub-suppliers. Such practice was observed in two cases: the base station equipment development project and the Asian car development project. The focal companies in those two cases both sought to exert their influence on sub-supplier selection indirectly through parts specification i.e. by virtue of the design by making part specifications very particular:

> *There is a fairly strong logic that says the person who holds the pencil actually holds the supplier selection as well because the person who does the design work can actually dictate who can make that part. So what we did was we ensured that where we found it important to use a particular supplier or that supplier's component, the best design was drawn up using that component.... So it was probably a little bit sneaky to do it that way but rather than have a fight with the joint venture and impose our will upon them*

[127] Many publications discussing network management and orchestration are arguably populist and promoted by management consultancies. The article by Häcki and Lighton (2001) provides one such

we took the view that the same result would be achieved by designing the vehicle around those standard parts.... We didn't specify those indirect suppliers, we specified which components had to be used and because they had a very limited tooling and development budget they were hamstrung – they could not then justify going and copying that part at another supplier. AutoEngineer Business Unit Director

In both the base station equipment development project and the Asian car development project, the focal firms exerted their influence on sub-supplier selection in collaboration, or at least consultation, with their customers. The customers did not appear to dictate supplier selection, but relied on debate and mutual compromise, thus again supporting the notion of 'uniting'. Whereas in the case of the fuel tank development project the focal company was significantly constrained in its attempts to unite with the suppliers of its own choice, other focal companies, including TelePart and AutoEngineer, were able to assume much more proactive roles in the 'sub-supplier' nomination process. Customer power was thus exerted in a more collaborative way (Frazier and Antia, 1995) in the cases of the telecommunications equipment development project and the Asian car development project compared with the fuel tank development project.

Secondly, the findings provided indications that companies frequently employed network co-ordination strategies to enable *mobilising*. The evidence was limited from focal firm analysis; only one focal firm, in the base station equipment development project, revealed any attempts to deploy co-ordination strategies to manage or at least influence mobilisation beyond its direct relationships: in this case it related to negotiation with sub-suppliers and 'driving' of delivery targets (in conjunction with the customer). Yet, when viewed from the perspective of focal firm customers, generally large OEMs, there was much more evidence of co-ordination of mobilisation. From the point of view of the focal firms, such co-ordination strategies often translated into constraints, most prominently in the case of the fuel tank development project, as will be discussed later.

Thirdly, companies attempted to employ co-ordination strategies to enable *communication* at the level of the network. Enabling of communication through the network was most evident in the case of the fuel tank development project. In this case the focal company's customer (a large Japanese vehicle manufacturer) clearly

example.

communicated information concerning, for example, design changes, terms and conditions, and cost/margin directly to a group of sub-suppliers. The strategy employed by the vehicle manufacturer was one of direct intervention; the vehicle manufacturer circumvented the focal firm in its communication with its own suppliers.

The dissemination strategy rarely proved to be conducted as an explicit deliberate strategy. It more often took the form of an emergent strategy (Mintzberg, 1992) of 'leaving it to the suppliers'. When companies made no attempts to co-ordinate activities, they tended to perceive their approach as 'effectively' a dissemination (or "cascade") strategy (Lamming, 1996; Lamming *et al*, 2000b). However, it was difficult to interpret a 'leave it to the suppliers' approach as a dissemination strategy, as no instructions had been given to disseminate. In the more implicit form that was observed in the cases, however, dissemination may have been used across collaboration activities, for example, relying on direct suppliers to decide on the timing of involvement of their own suppliers. It should be noted that part of the explanation for the lack of more specific and extensive results on the application of the dissemination strategy, might be methodological, specifically the way in which interviews sought to capture the dissemination strategy. This issue is further discussed in the lessons at the end of this chapter.

The cases revealed several examples of focal company intervention strategies. Such examples included sub-supplier nomination, or in other words, focal firms seeking to influence uniting of network actors beyond 'direct' (supply) relationships and sub-supplier communication. Therefore, the cases provided initial evidence that uniting (and indeed supplier selection) was not merely a dyadic activity. It concerned the uniting of a potentially large part of the network, although intervention appeared to be a one-way process, where the customer specified or nominated an indirect supplier, thus leaving the direct supplier, which was to work with the customer-specified supplier, limited flexibility in its own choice of suppliers. Given the nature of the focal companies in the cases, it was perhaps not surprising that network intervention appeared to be more elaborately performed by the focal companies' customers, in most cases OEMs or assemblers, rather than the focal companies themselves (this issue is examined in Section 8.2.5). Intervention seemed to be an important strategy, which was practised by several actors involved in the case studies, particularly to enable the activities of uniting and communicating. Such intervention can be seen as increasingly critical, as the need for innovating companies to control *which* parts and technologies enter their offerings and *how*, is increasingly not only a regulatory but also an ethical and environmental requirement (Smart, 1992).

The findings support the notion that network co-ordination is not merely confined to large powerful assemblers or 'hubs'. Instead there are indications that networks are becoming increasingly complex; even the automotive case studies showed that suppliers rather than vehicle manufacturers performed key co-ordination roles in product innovation activities:

> *I don't think it is [the vehicle manufacturers who specify the supplier network], any longer. Certainly the Japanese transplants in Europe and more and more the other European suppliers..... will decide that they want a steering wheel that performs to a certain number of prescribed measures.... and select the supplier for that - then that tier 1 or tier 0.5 supplier has the responsibility to then cascade those requirements down through the supply chain. It used to be the case where [vehicle manufacturers] would actually go down to the last nut and bolt in order to understand it. But now I think that's less and less because the vehicle manufacturers have become more assemblers...[with major tier 1 suppliers] who perhaps take that responsibility on. But that wasn't possible in [Asia] because they're not developed enough to be able to do that.* AutoEngineer Business Unit Director

Thus, this view reflects the suggestion that increasingly it is large 'first tier' suppliers rather than vehicle manufacturers that perform important network co-ordination tasks, although the apparent resistance of some vehicle manufacturers to cease their network controlling behaviour, as in the case of the fuel tank development project, may hinder this transfer process. This apparent shift in network power and responsibility concurs with the findings of e.g. Baldwin and Clark (1997) and Doran (2003) and reflects a move across several industries toward modularised product architectures and systems offerings. This will be discussed in more detail in section 8.5.

8.3. Effect of Risk of Dissipation of Knowledge on Different Collaboration Activities in Product Innovation Projects

The risk of dissipation of knowledge through network interconnections was conceptualised as a potential network constraint. This network effect featured strongly in the exploratory mini-survey and was also evident in the case studies. Consistent with the exploratory mini-survey findings, the case studies suggested that some of the companies involved had experienced problems as a result of lost knowledge through network connections to competitors, most notably the fuel tank development project. Companies in other cases were also concerned about losing knowledge.

However, only the conduct of one activity seemed to be affected by the risk of dissipation due to network connections: communicating. It may also have impacted upon the two activities of uniting and human resource exchange by excluding activities with non-trusted actors.

The finding that communicating was the only activity that appeared to be seriously hampered by risk of dissipation of information and knowledge to network actors may not be surprising given the logical link between this type of network effect and exchange of information and knowledge. The extent of communication in most cases was generally conducted on a 'need to know' basis. Some actors seemed to make clear distinctions between the levels of communication within high versus low involvement relationships, thus providing much more extensive and open information to high-involvement collaborative actors. Many respondents across the cases also claimed that risk of dissipation of knowledge was not a real issue as they would only work with trusted companies and would have formal non-disclosure agreements as support. The general assessment was often that if a company was deemed appropriate to be involved there should be no reason to hide anything. Hence, a sense of professionalism seemed to minimise the magnitude of the problem, however, many respondents still admitted that they had been less than fully transparent e.g. at certain critical points during projects. The issue of actors withholding information may be explained by the fact that many of the relationships across the cases were not - explicitly or implicitly - classified as 'strategic partnerships'.

Although the process of uniting was hampered by fears of dissipation of knowledge and technology to third parties in two cases, this potential problem generally seemed to be managed through exclusion of suppliers that had failed to respect confidentiality in the past (hence also related to path dependency). Thus, the risk of dissipation of knowledge did not appear to present a major constraint on uniting, only in the sense of excluding actors that had failed to respect confidentiality in the past.

The limited extent of human resource exchange, which was uncovered, did not appear to be restricted by any concerns over the risk of dissipation of knowledge and technology to third parties, although it was likely to have been one reason for the absence of this activity in the base station equipment development project. Again any perceived risks were generally managed through trust (and often supported by formal non-disclosure agreements). In cases of high confidentiality, a common practice was to ensure that any external residents did not have access to restricted areas.

The findings are consistent with much existing research, including Bower and Whittaker (1993) and Bower and Keogh (1997), although their observation that many risks were not recognised by the firms involved in their study did not appear to be evident in the cases. Most of the firms in the study seemed to be well aware of the inevitable flip side of collaboration, that is, risk of dissipation of knowledge and technology to collaboration partners and third parties: it was regarded as a risk with which companies simply had to cope and most companies seemed to cope in a very professional manner, respecting confidentiality and commercial sensitivity with or without contractual back-up.

The findings concur with the literature on trust, which discusses trust as a more effective alternative, or supplement to, contractual mechanisms (Sako, 1992; Granovetter, 1985; Thorelli, 1986; Kumar, 1996; Doz, 1996; Kale *et al*, 2000; Dyer and Nobeoka, 2000), and as a way to prevent opportunistic behaviour (Gulati, 1995; Bradach and Eccles, 1989; Ring and Van de Ven, 1992; Madhok, 1995). The expression 'brick walls' was used by one of the interviewees in the exploratory survey and is consistent with the similar idea of 'Chinese walls' as referred to in Ford *et al* (2003). The notion of 'walls' provides an effective metaphor for understanding the segregation and protection of sensitive information and seems to capture how many respondents in the cases viewed the mechanisms for avoiding dissipation of information and knowledge. As Bower and Keogh (1997) observed, actors often have to cope with the dilemma of meeting the same people in different capacities or for different projects and not being able to reveal any information or knowledge that may have been discussed at prior meetings (a dilemma also faced by, for example, 'Bio-Pharm' in the exploratory survey). A 'Chinese wall', though, may be too strong a metaphor as it indicates a very strong boundary. The findings generally support the notion of fuzzy fluid boundaries. However, for coping with the risk of spill-over to competitors, Chinese walls may constitute an essential mechanism. Segregating knowledge also appears to be a key factor in Toyota's approach to coping with the problem of loss of knowledge (Dyer and Nobeoka, 2000).

True transparency only appeared to exist in a few select relationships examined across the cases, although this may be explained by the fact that many of the relationships were not considered highly collaborative. The findings therefore indicate that the concept of transparency, initially in relation to cost (Lamming, 1993) and later value (Lamming *et al*, 2001) is an ideal which is likely only to be applicable in highly collaborative relationships characterised by high levels of mutual trust. Communication was generally more translucent in the cases than truly transparent. In other words, there were elements of information and knowledge not being openly shared, even within the most collaborative relationships examined in the case studies in this thesis.

8.4. Effect of Different Types of Dependency on Different Collaboration Activities in Product Innovation Projects

The network literature had revealed a number of dependencies attributable to embeddedness in networks. Such dependencies included administrative, logistical, technical, knowledge, social, and path dependencies. It was decided to focus upon technological dependence (including both technical and knowledge dependencies), administrative or logistic dependencies (as one), and path dependence. Social dependencies were not included as it was seen as a large but somewhat distinct area in itself.

The empirical findings indicated that all activities except from human resource exchange (where the findings were limited) were constrained by different forms of dependency effect. This means that as a result of network dependency constraints, the management of the set of collaboration activities was at least partly out of the control of individual focal actors; focal actors were dependent on how other network actors conducted collaboration activities in their parts of the wider network.

8.4.1. Administrative and Logistical Dependency Effects

The concept of network co-ordination was constructed as a network enabler, but emerged from the findings as a simultaneous network enabler and constraint, depending on the perspective. Notably network co-ordination was in the form of intervention, which affected the ability of focal companies to control their own collaboration activities. Intervention could be seen as a form of administrative or logistical dependency exercised by a dominant actor, or 'hub', and affecting other network actors, including the focal companies in the cases. The picture was therefore interactive: actors affected other network actors and their activities, actions and strategies, but in turn they were also affected by their activities, actions and strategies. Administrative and logistical dependencies were thus mutual.

Administrative and logistical dependencies were most evident in cases that spanned international boundaries, for example, involving joint venture-based foreign direct production capability investments, notably in the Asian car development project, but also in the fuel tank development project. This indicated that the more international or global an innovation project the more problematic it was to control the innovation process due to administrative dependencies. This finding concurs with Håkansson's contention that administrative dependency may become more important due to increasing internationalisation (1987).[128] However, the findings specifically identified that all the collaboration activities included in the conceptual structure, apart from exchanging human resources, were problematic to manage and control due to administrative and logistical dependencies.

The case studies revealed that administrative dependencies were often of a legal and commercial nature. None of the conceptualised forms of dependency appeared to fully capture these dependencies. One example of a 'legal dependency' concerned the problems which actors experienced in formalising contractual agreements. An example of what could be described as commercial dependency included different levels of commitment and priorities amongst inter-connected customer relationships. This type of dependency may be viewed as fundamental and was by no means surprising. Nevertheless it did not appear to have been fully incorporated into any of the forms of

[128] Indeed Håkansson made this observation in 1987 since when the trend towards globalisation has truly surged (Dicken, 2003). As a tentative hypothesis, administrative dependency due to global industrial networks can thus be expected to be a highly relevant problem across industries.

dependency that had been conceptualised. Cousins' (2002) concept of 'economic dependency' may come closest to the concept of 'commercial dependency' proposed here. The conceptual lesson on this type of dependency is further discussed in section 8.7.1.

Administrative/logistical dependency effects on uniting

Across the case studies, the process of uniting was significantly inhibited by the practice of sub-supplier nomination, indicating an administrative dependency. Administrative dependency affected uniting in three of the four cases, but most strikingly in the case of the fuel tank development project where the choice of the most important suppliers of the focal company was practically dictated by the customer. Dictation had a series of associated negative effects on EuroPart's ability to manage and control not only its immediate network situation but also its longer-term strategic direction.

The practice of customer intervention in sub-supplier selection was performed most directly in the case of the fuel tank development project. In the cases of the Asian car development project and the base station equipment development project, intervention was more indirect and subtle, as the customers attempted to influence sub-supplier selection, but in a less dictatorial, more collaborative manner. In the base station equipment development project, the customer of the focal firm required its direct suppliers, including the focal company, to unite with suppliers as specified on an approved suppliers list. In the case of the Asian car development project, the customer of the focal firm sought to exert its influence on sub-supplier selection through discussion with the focal company (AutoEngineer). Thus, the cases revealed different practices of customer intervention in sub-supplier nomination. At one end, the practice was dictatorial and essentially non-collaborative. At the other end, the practice was more collaborative, leaving more space for the supplier to decide with whom to unite.

Administrative/logistical dependency effects on timing

The process of timing only seemed to be affected by administrative dependencies in one case, the case of the Asian car development project. However, in this case it presented a significant constraint, resulting in late supplier involvement. The administrative dependency in the Asian car development project case resulted from problems in formally agreeing and arranging a joint venture agreement, which was fundamental to the initiation of the project. The joint venture agreement was part of a turnkey project, involving the construction of a plant for vehicle production in Asia. Hence, the administrative complexity in the case of the Asian car development project was high, albeit not an unlikely scenario as networks become increasingly global.

Administrative/logistical dependency effects on synchronising

Closely related to timing was synchronisation, which also was a key part of innovation project management. Only the case of the Asian car development project exhibited any apparent dependency effects on synchronising. Specifically, the administrative dependency, which originated from the customer's joint venture formalisation process, inhibited AutoEngineer's efforts to synchronise effectively with its suppliers.

Administrative/logistical dependency effects on mobilising

The process of mobilising appeared to be inhibited by administrative or logistical dependencies across all four cases. Mobilisation problems were related to customer intervention in commercial arrangements with sub-suppliers, such as in the case of the fuel tank development project, and intervention in joint venture arrangement difficulties, such as in the case of the Asian car development project. Such problems left many suppliers across the cases frustrated and disillusioned.

Another form of administrative dependency was evident in the two telecommunications cases. In those instances this concerned the level of resource allocation depending on the relative importance of the customer. In the case of the interception gateway development project there was a perceived lack of commitment due to the supplier having more important customer relationships. In the case of the base station development project this was illustrated by the supplier classification framework of the customer, which specified a higher level of mobilisation, for example in the form of extensive 'frame agreements' and risk and reward sharing agreements, with highly dependent suppliers.

Administrative/logistical dependency effects on communicating

The most strongly affected case of administrative dependency on communication seemed to be the fuel tank development project, which was circumvented by its key suppliers and customer in the communication of e.g. design changes, terms and conditions, and cost and margin information. One of EuroPart's suppliers expressed its sympathy with EuroPart's inability to control its communication within the network:

> *This is where it probably in a way works against [EuroPart] in that there's a very transparent pricing system. [The vehicle manufacturer] know exactly what price I'm selling it to [EuroPart] at. Whereas I guess if it's a normal supplier down the road, if [EuroPart] can get a very good price for it, then that's [EuroPart]'s good purchasing. For the parts that we supply it's the case that I tell them what the price is and I tell [the vehicle manufacturer] what the price is...*

This quote indicated that the circumvention strongly affected Europart's ability to conduct and control its activities. Even worse, the system of enforced cost transparency constrained EuroPart's ability to make a viable profit. On the one hand, the vehicle assembler might have viewed the method as a cost efficient way to apply its purchasing leverage and, perhaps, perceived superior negotiation skills (Ellram and Billington, 2001). On the other hand, the focal company might compensate for the presumed advantage of purchase leverage by having a superior knowledge of its own local suppliers with whom it has an established long-term relationship. This research did not attempt to measure the efficiency or effectiveness of either arrangement. This therefore constitutes an area of further research.

The joint venture problems in the Asian car development project had similar consequences to the problems experienced by EuroPart in the fuel tank development project. In this case the joint venture problems prevented AutoEngineer from receiving and thus providing complete and detailed information about critical project details.

Administrative/logistical dependency effects on problem solving

Administrative dependency related to perceived supplier problems in balancing different customer projects and priorities. This was prevalent in the two cases of the base station equipment development project and the Asian car development project. In those two cases, the customer perceptions were that some suppliers were unable to allocate sufficient resource and commitment to resolving problems within their project. As discussed earlier, such dependency could be viewed as a form of 'economic dependency (Cousins, 2002).

Administrative Dependency Effects: Supportive or Interfering Intervention

Intervention took different forms across the cases. In some cases OEMs intervened in positive ways by assisting or *supporting* the focal companies in a collaborative fashion, for example, in identifying suitable sub-suppliers. In the cases of the base station equipment development project and the Asian car development project, the nature of the intervention was largely characterised by mutual agreement and consensus between the focal companies and the OEM customers. The focal companies did not appear to be severely constrained in their actions, albeit inappropriate intervention was seen as frustrating, as it added no apparent value but plenty of obstruction. From the vehicle manufacturers perspective, of course, their intervention might have been regarded as essential to ensure that the time and effort they had invested in those indirect specified relationships would not be wasted (Humer, 1998).

Intervention could also take on a much more destructive, *interfering* (Lamming *et al*, 2000b; Lamming 1996) or dictatorial form when viewed from the focal company's perspective. In such cases power was exerted in a coercive rather than collaborative way (Frazier and Antia, 1995; Ford *et al*, 2003). In some cases, it became clear how one actor's network intervention, seeking to enable an activity from its position, often became another actor's constraint. The overall performance impact of such interference was difficult to establish. However, there were indications that customer interference created a variety of problems for the focal companies, most notably EuroPart. Evidently, interference prevented focal companies from pursuing their own strategies and controlling their own business offerings.

8.4.2. Path Dependency Effects

In addition to the administrative dependency effect in connection with sub-supplier intervention in the selection process, another form of dependency, namely path dependency, was also revealed. Path dependency was manifested either in the form of a poor record of accomplishment inhibiting future involvement, which was the case in the interception gateway project, or through the difficulties of submitting new suppliers to extensive qualification processes, in the case of the base station equipment development project:

> *If there is any deviation from that parts list then it would need to go back through the re-approval process, which costs thousands of pounds and time of the engineers. So once we have produced this product and it has been approved by TelePart and [its customer] with the range of components then that is set in stone and we can't deviate from that particular range of components. There is a fixed number of alternative*

manufacturers that TelePart and [its customer] would accept. Operations Manager, TelePart Supplier

Path dependency effects on *communication* were observed in the two cases of the Asian car development project and the base station equipment development project. Path dependency was manifested through the records of accomplishment of suppliers and their ability to respect confidentiality; untrustworthy suppliers would be classified as 'non-preferred'. Less predictable was the path dependency example in the case of the Asian car development project where its poor past experiences with vehicle manufacturers led it to restrict the openness of its communication. Thus, the Asian car development project case appeared to constitute another example of path dependency in the shape of poor experience or performance. Unsurprisingly, the reverse effect of path dependency was also evident within this activity. In other words, positive past experience enabled communication.

Path dependency effects on *problem solving* were observed in the base station equipment development case where the change-averse attitude of some staff involved in problem solving reportedly constrained adoption of new ideas and solutions that would resolve problems.[129] In the case of the Asian car development project, path dependency constrained the process of problem solving in two ways and at two different levels. Path dependency constrained problem solving at a dyadic level through the lack of history between the focal company and the key customer resulting in limited mutual understanding. The lack of history thus meant lack of path dependency. Hence, it may be problematic to describe as a path dependency effect, as it was more related to past dependence than path dependence (Araujo and Harrison, 2002).

Although path dependency was conceptualised as a network constraint it emerged that it simultaneously enabled several activities, including uniting, communicating and problem solving. For example, a positive record of accomplishment was an enabling factor in the ability of suppliers to become involved in new projects, indeed in some cases this was a precondition as this had generated trust and thus reduced the risk often associated with involving new unknown suppliers. This is consistent with recent research on technological innovation in industrial networks. The findings by Håkansson and Waluszewski, which were published in parallel with the writing up of this thesis, have shown that path dependence can facilitate technological development when solutions that are historically embedded in networks are confronted with new opportunities (2002). Thus, path dependence can contribute to technological development through alternative uses of existing knowledge, the 'black-boxing' of some problems and allowing developers to focus their efforts on other, more restricted and soluble problems (Araujo and Harrison, 2002).

8.4.3. Technological Dependency Effects

Technological dependency effect: timing

Technological dependency had important bearings on the management of timing, especially in relation to the problem of whether to produce technical specifications in-house or assign this responsibility to suppliers. NetCom had involved its supplier after the specification stage, but realised in hindsight that the supplier would have been technically more competent to produce the specification, or at least be involved in the specification process. TelePart was in much the same situation, but had not quite made the realisation that suppliers could add significant value to the specification process and thereby help to avoid later quality and cost problems. Both of these focal companies had internal design specification competencies, which had hitherto dissuaded them from allowing suppliers to assume the responsibility for the specification process. Still, they relied on their suppliers to respond to the specifications, although changes to the specifications would not be easy to implement. The lack of focal company competence trust in the suppliers' abilities to produce design specifications, seemed to be one contingent factor that influenced this decision.

Technological dependency effect: uniting

The case of the fuel tank development project showed how a company can lack the full technical control over its own module design and manufacture due to extensive customer intervention, or administrative dependency, in choice of sub-supplier and hence technology. Uniting was therefore constrained by technological dependency effects in one case.

[129] The extent to which this can be attributed to a 'network effect' may be weak. It has been included here because it related to a historical development within individuals as well as relationships.

Technological dependency effect: synchronising

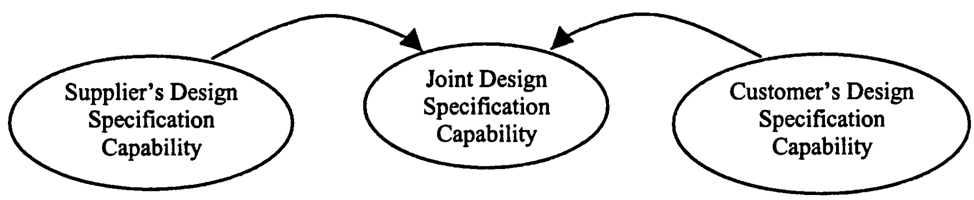
Long-term synchronisation in the form of strategic alignment was affected by technological dependency. In two cases, the base station equipment development project and the interception gateway development project, this related to either customers or suppliers being reluctant to share technology road maps with the focal firms. Such reluctance appeared to concern relationships in which the actor was relatively less important compared with other actors. Technological dependency at a higher network level also affected synchronisation. This was observed in the case of the interception gateway development project, as it needed to comply with and adapt to a complex set of third generation telecommunication standards.

Technological dependency effect: problem solving

In the case of the Asian car development project, the lack of technological path, given the level of technology newness to the focal company, meant that there were no established ways of resolving the technological challenges that transpired. Thus, this concurrent path and technological dependency appeared to constrain the problem solving process.

An implication of the findings on technological dependencies on different collaboration activities concerns the problem of core competencies. It was discussed in Chapter Three that a network perspective implies that core technologies and competencies become vested in relationships rather than within companies and that multi-technology corporations have distributed rather than distinctive core competencies (Granstrand *et al*, 1997). Competencies become network, or *networking*, competencies (Ritter, 1999). Technological dependency had important bearings on the problem of whether to produce specifications in-house or assign this responsibility to suppliers. The cases indicated that some companies were beginning to realise the potential benefits of involving the supplier in the specification stage, although often companies had seen the development of design specifications as an internal R&D core competence. However, the timing question regarding when to produce specifications in-house or allocate to the supplier (Wynstra, 1998; Handfield *et al*, 1999; Bonaccorsi and Lipparini, 1994) did not seem necessarily to be an either/or decision. Rather, some companies in the cases were reaching the point where they began to believe that the right decision would be for customer and supplier to jointly produce specifications. Conceptually and practically this has significant implications, because it means that the competence related to the development of technical specifications may increasingly become shared rather than existing within either party. It becomes a relationship-specific competence rather than an internal competence residing within companies. Using the concept of quasi-firm suggested by Blois (1972) the technical specification competence may be conceived of as belonging to the quasi-firm rather than either the customer or the supplier. The customer retains the overall control of the technical specification process, even though its dependency on key suppliers increases due to supplier-produced detail specifications (see also Karlsson *et al*, 1998). Figure 30 builds on the idea in Figure 13 regarding 'quasi teams', to illustrate the implication of such a shift in design specification competence.[130]

Figure 30. From Internal to Joint Design Specification Competence



Thus, the case studies have shown how the activities of uniting, timing, synchronising and problem solving were constrained by technological network dependency. The findings on technological dependencies have also indicated that some companies may be starting to realise the potential for joint capabilities e.g. in the production of design specifications. Ford and Saren (2001), Granstrand *et al* (1997), and Gadde and Jellbo (2002) have argued that as companies are increasingly outsourcing not only non-core technologies, but potentially also core technologies, technological dependency increases. The cases indicated that companies may be reluctant to lose internal design specification capabilities, thus giving away the control of the design specification process. The cases, however, pointed to a number of advantages of allowing suppliers to assume at least part of the control over the design specification process. Some companies appeared to be ready to make the leap towards joint design specifications, although not without trepidation due to their fears of losing control over what they perceived as a core competence.

[130] The development towards joint design specification capabilities concurs with a black-box engineering process where the supplier develops and successively presents a set of different specifications based on

8.5. Situations of Appropriate Network Co-ordination Strategies

A number of situational or contingent factors were investigated in the case studies. Some of these were explored as part of the interview guide structure, first of all Interview Guide One (Appendix B) and first parts of Interview Guides Two, Three and Four (respectively Appendices C, D, and E). As explained in sections 5.6.2 and 5.6.3, other situational factors emerged from the cases and were identified through a process of annotation, coding and categorisation (Miles and Huberman, 1984). Some of these were captured through analysis of the collaboration activities and network effects. For example, issues of power emanated from discussions of different forms of dependency (see Appendix G). Hence, although related to the *a priori* defined constructs, some situational factors simply emerged from the case analysis (Eisenhardt, 1989). Table 25 provides an overview of the situational factors that were identified through this process of analysis.

the initial framing guidelines transmitted by the customer (see also Section 3.1.3 and Karlsson *et al*, 1998).

Table 25. Key Contextual Factors Across the Four Case Studies

	Fuel Tank Development Project (Pilot Case)	Asian Car Development Project (Case No 2)	Base Station Equipment Development Project (Case No 3)	Interception Gateway Development Project (Case No 4)
Innovation	Recent material / process technology applied in car project: incremental product development/ introduction	New body-in-white material applied first time in high-volume vehicle production: radical innovation (in auto industry)	Updating previous product: incremental product development/ introduction	Part of major systemic shift from (2G) voice to (3G) data transmission: specific project is incremental innovation, as builds on previous product technology
Product being developed: Architecture & Product/Part Criticality	Modular architecture. Fuel tank a (safety) critical component & highly specified.	Modular architecture. Most parts of car low cost 'minimum' specification, but contains safety-critical parts.	Modular architecture. Driven by cost & minimum specifications: relatively limited criticality.	High software content. Complex integral architecture, Driven by legal requirement, cost & minimum specification / commercial criticality.
Supplier Competence Trust	FC customer (J-Car) has limited competence trust in FC: trusts long-term Japanese suppliers (culturally closer). FC trusts some suppliers but mistrusts key supplier nominated by J-Car (mutual).	FC JV customer is partly global vehicle manufacturer, partly Asian JV partner: JV limited experience, relies on & trusts more experienced FC. FC trusts prototype suppliers (long-term relationships) but has limited experience with/trust in new Asian production suppliers.	FC customer (TM) lacks complete trust in FC's ability to manage project but trusts its technological capabilities. FC trusts few of its suppliers, particularly in relation to technological capability.	FC trusts key supplier's technological capabilities but not its ability to manage project. Different national cultures seem to restrict trust.
Focal Company Network Power	J-Car is powerful Japanese vehicle manufacturer: dual sources & hence limits dependency on FC. J-Car exerts power through sub-supplier nomination.	VM very powerful but JV limited power due to lack of experience in Asia, single-source strategy with FC, & FC portfolio of customers: FC customer highly dependent on FC – limits customer power.	TM is global telecoms network provider. Its power reduced in particular project by TM single source strategy & TM's large use of FC. FC has 60-70% of business with TM: FC highly dependent on TM but elements of mutual dependency limits TM power.	FC customers are national law enforcement agencies (LEAs) & network operators. FC powerful: several customers. FC uses one supplier of product/single source. Supplier powerful as only one of two international players.

Note: FC: Focal Company

It is clear that the four case studies, whilst they shared some common denominators, differed widely in terms of situational characteristics. An apparent difference concerned the nature of the focal companies. One of the cases had as its focal company an assembler, NetCom, whereas in the three other cases the main roles of the focal companies were as suppliers to assemblers, or 'first tier suppliers'. As a differentiator, however, it is imperfect. For example, AutoEngineer's role was not only a 'first tier' supplier, as it frequently operated as a vehicle assembler in other projects. In the project studied, AutoEngineer would not have final assembly responsibility but its turnkey role not only included setting up a plant, but also managing, or convening (Lamming *et al*, 2000b), the development of an industrial network, or at least part of it. Furthermore, as a situational factor the role of the focal companies may be an inappropriate differentiator, because it does not differentiate the cases but merely the focal perspective within each case.

A key situational factor related to the actual projects constituting each case study. The interception gateway project involved the development of a component technology that would form part of telecommunications networks. Hence, it would form part of a large and complex system: itself a technological network. This was in many ways comparable with the base station equipment development project. The Asian car development project concerned the development of a car, or in other words an end product, although the focal perspective was that of an engineering supplier, with a wide-spanning role. In comparison, the case of the fuel tank development project focused on the development of 'parts' for a relatively simple end product: a car.

Closely related to the nature of the projects of the four case studies, was the level of innovation involved. Despite the ambition to identify and focus on innovative projects, critical assessment of the projects revealed that only one of the projects, the Asian car development project, involved what could be described as radical innovation (Lundgren, 1995). This was in the form of the application of a new to the industry material (Gobeli and Brown, 1987). Although radical, the innovation could hardly be described as discontinuous or disruptive (e.g. Linton, 2002; Kassicieh *et al*, 2002). The other three cases concerned innovations that could most accurately be described as incremental, even if one of them, the interception gateway project, was part of a major systemic innovation (Freeman, 1994; Teece and Chesbrough, 1996) moving from voice to data transmissions.

When abstracting from the pre-defined situational, or contingent, factors, a number of additional factors emerged as 'causal powers' (Easton, 1998; Sayer, 1984). Indeed, network co-ordination strategy patterns seemed to relate to a specific combination of these pre-defined and emergent contingent factors. These are discussed in the following.

8.5.1. Power

The literature indicates that companies may often favour intervention if they are in a position of power and/or possess the capability to intervene (Harland *et al*, 2001). The explanation for the different levels of customer intervention in uniting across the cases may well lie in the relative dominance or power of the respective customers (Cox *et al*, 2000). A common feature of the customers of the three focal companies, EuroPart, AutoEngineer, and TelePart, was that they all were, or were part of, major global OEMs. In the case of the Asian car development project the customer company consisted of a joint venture, involving a global vehicle manufacturer as one of the partners. However, the joint venture itself was not very powerful due to its limited experience in setting up a new plant, supply base, and developing an innovative new vehicle, all at the same time. Hence, the managerial and technical systems capabilities (Leonard-Barton, 1992), or using the terminology of Ford and Saren (2001), the product, process and marketing technologies of AutoEngineer in this particular project were relatively superior to those of the joint venture in managing this complex project. These factors contributed to placing AutoEngineer in a position of power, and thus influence, in relation to the joint venture customer.[131] In the case of the base station equipment project, the customer 'TM' was an equally large global actor and its position was not compromised by any joint venture partners. It had significant power over the focal company, TelePart, not least because of its high dependence on TM. The dependence, however, was to some extent mutual as TM relied on TelePart as a single source for the development of the base station equipment. This was a common strategy by TM in its relationship with TelePart, which would usually, in other projects, be balanced with a dual source to avoid a high degree of dependency. In comparison, the powerful network position of EuroPart's customer, J-Car, in the fuel tank development project was much more straightforward. J-Car pursued a deliberate dual sourcing strategy to enable it to shift supplier if required and dependency was much more unidirectional. J-Car exerted and thereby manifested its power through its intervention strategy, for example, in sub-supplier nomination. Its power was thus sovereign and utilitarian (Lukes, 1974). The case of the interception gateway project did not have any one powerful sovereign actor. The national law enforcement agencies naturally possessed some power given their regulatory position. The focal company NetCom, however, was also a large global and powerful actor. Its supplier in the case study was relatively small, but its strong duopolistic position in the market as only one of two international suppliers was a significant source of power. Power was thus more dispersed in the interception gateway development project compared with the other projects, particularly the fuel tank development project.

The relative significance of power seemed to be linked to different patterns of network co-ordination strategies and thus a key situational factor. The case in which network intervention was most evident was the case with the most obviously powerful customer relative to the focal company being subjected to intervention. In comparison, the other cases included more examples of what may have been implicit use of dissemination strategies, for example, in uniting and communicating.

The cases also illustrated the different workings of power when applied to network intervention. As identified by Frazier and Antia (1995) power may be applied either coercively or in a collaborative way. The intervention in the cases exemplified what could be interpreted as coercive power and it seemed that such power was particularly applied in relatively non-collaborative relationships e.g. in the relationships surrounding EuroPart in the fuel tank development case. The following quote illustrates the contrast between the power of the powerful vehicle manufacturer J-Car and suppliers and the amount of deference shown by suppliers in the face of powerful customers:

> *[The Japanese rubber suppliers] are not so flexible, we're a long way away and even if my colleagues in Japan go to see them it's them as J-Car Commerce Japan. If J-Car Japan are going to see them, then the flags will be out and everybody will be sweeping the streets and things.* (J-Car Commerce)

The exertion of power in other cases seemed to be more collaborative. For example, although dealing with powerful customers in one sense, TelePart and AutoEngineer were still able to assume very proactive roles in the sub-supplier nomination process, or uniting. This is consistent with the suggestions by Ford *et al* (2003) that coercive power is mostly of relevance to low-involvement relationships.

[131] Given the focus on developing a supply base in the car development case 'supply technology' might be a more accurate term than marketing technology.

It is interesting to note that in concurrence with Ford *et al* (2003) the case studies featured power as a key explanatory factor despite the fact that the case studies concerned collaborative innovation projects. This supports the notion that collaboration by no means implies that power and indeed conflict become less important. As discussed in this section it would appear that the exertion of power through intervention strategies is linked to the level of collaboration within network relationships. This leads to the second apparent situational factor: competence trust in suppliers.

8.5.2. Competence Trust in Supplier

There were signs that the perceived relative competencies of the focal firms vis-à-vis the customers and suppliers affected the type of network co-ordination strategy that was favoured. The fuel tank development case, in which there was extensive customer intervention, was characterised by a lack of competence trust (Sako, 1992) in EuroPart. There were indications that the limited competence trust by J-Car related not only to EuroPart but also to European suppliers in general, although the limited and possibly biased statements on this by respondents means that this cannot been verified. It seems reasonable to assume, however, that J-Car had a higher level of competence trust in its domestic long-term suppliers in which much time and effort had been invested. Nevertheless, the explanation in that particular case may be that trust between different cultures may be difficult to establish (Johanson and Vahlne, 1977; Ford, 1980) and thus encourages the application of network intervention strategies. In comparison, there seemed to be relatively more competence trust in the other three case studies. In the Asian car development project, there appeared to be trust in the relationships between AutoEngineer and VM and AutoEngineer and its prototype suppliers. AutoEngineer did not trust many of its new production suppliers, however, and applied network intervention, by virtue of narrow product specifications, in the uniting with some sub-suppliers. The different national cultures of Asian production suppliers may be an added factor in explaining the lack of competence trust, but also the immaturity of the relationships (Ford, *ibid.*). In the base station equipment case TelePart's customer, TM, evidently lacked trust in TelePart's ability to manage the project, or in other words its managerial systems capabilities (Leonard-Barton, 1992). Nevertheless, it did not appear to lack trust in its technological capabilities or product technology (Ford and Saren). This seemed to be a key factor in explaining the joint nature of the intervention that was conducted in the base station equipment case, for example, in uniting with the focal company's sub-suppliers. The situation in the interception gateway project was similar in many ways, as the focal company trusted the technological capabilities of the key supplier, but had little competence trust in its ability to manage the project. Also in this case there was limited network intervention, and 'implicit dissemination', or delegation, and network access strategies seemed to be more prevalent. The cases therefore indicate that there is a possible link between the level of competence trust in suppliers and the form of network co-ordination strategy applied by network actors.

As identified in the literature review in Chapter Three trust has been described in a range of studies as an important mechanism, which can contribute, along with other relationship characteristics such as commitment (e.g. Ring and Van de Ven, 1994), to preventing the occurrence of opportunistic behaviour (e.g. Sako, 1992; Thorelli, 1986; Kumar, 1996). The role of trust is therefore well-established as a way of safeguarding against opportunistic behaviour. Thus, the perceived capability or competence of, and therefore trust in, the supplier to manage the process without intervention from the customer, seems to be another contingent factor; this is supported by a wide body of literature on trust.

8.5.3. Product Architecture

A further explanatory factor in explaining the different levels of customer intervention in sub-supplier nomination seemed to be the product architecture and thereby structure of the *supply network* (Harland, 1996; Gadde and Håkansson, 2001; Johnsen *et al*, 2000). These two inter-linked factors may be prominent in explaining patterns of customer intervention. It was discussed in Chapter Three how companies are increasingly relying on external companies to develop, manage and supply technology, which often comes in bundles that form part of complex system offerings (Granstrand *et al*, 1997; Gadde and Jellbo, 2002). The findings support the recent suggestions that there is a trend towards large system suppliers assuming more responsibility on behalf of assemblers (Baldwin and Clark, 1997; Doran, 2003). In Chapter Three the implication of such network restructuring change processes was discussed; one major implication is that individual actors become more dependent on other actors in order to perform their own activities and thus lose control over resources and technologies.

Different forms of product architecture and supply network structure seemed to be key factors in explaining the different patterns of network co-ordination that were observed. The case with the most obvious network intervention was the fuel tank project. In this case the part (i.e. the fuel tank) and the end product in which it was to form a part (i.e. a car) were both characterised by a high level of modularity. Similarly, the Asian car development and the base station development projects featured examples of network intervention, although in a more collaborative style involving both the focal companies and their customers. In comparison, the interception gateway development project case was unique in its virtually complete lack of sub-supplier intervention. It emerged from discussions with respondents in the interception gateway project that the large proportion of software components in addition to the complex non-modular or integral product architecture rendered customer intervention in, for example, sub-supplier 'nomination' obsolete. Sub-supplier 'nomination' would have been problematic because the integral product architecture implied a high level of component inter-dependency and thus a tight rather than a loose coupling between individual components (Sanchez and Mahoney, 1996; Ulrich, 1995). Thus the substitution of one supplier for another would have been highly problematic. This supports the notion of modular *supply network* architectures featuring multiple, interchangeable suppliers, standardised interfaces, systems sourcing, and volatile geography (Gadde and Jellbo, 2001; Araujo, 2003).[132] The inter-changeability of suppliers appears to be key to understanding network intervention; it is related to the characteristics of interactions between modules being well-defined (*interfaces*), which allows design change in one module without changes in other modules (*decomposability*) (Ullrich, 1995). Hence, network intervention strategies may only be feasible and practicable in modular product and network structures. Conversely, non-modular integral product and hence supply network structures do not appear to offer the flexibility required for network intervention.[133]

[132] It is important to bear in mind the difference between supply networks and wider industrial networks, as discussed in Chapter three. It is not suggested here that the wider industrial network structure is a result of product architectures.

[133] It may be relevant to note that it has been observed that Japanese vehicle manufacturers have been relatively slow to adopt modular product strategies compared with some of their Western counterparts (Sako and Warburton, 1999).

8.5.4. Product or Part Criticality

The lack of commercial necessity seemed to be another factor that contributed to the preclusion of attempts to intervene. The findings indicated that intervention requires availability of or investment in resource; hence if a product or part were dominated by cost considerations, the benefits of intervention would be unlikely to justify the costs. The Asian car project showed that the product or part criticality in terms of quality and technical performance was an added factor for companies considering whether to rely on an intervention or a dissemination strategy:

> *Fortunately, this product doesn't have very exacting performance requirements. Our strategy would have been very different if it was a luxury car or a high end of the market car. This is very much entry level so performance of seals and mechanisms and locks and latches isn't as demanding as it would have been if it were a European organisation. [Then] we would've had to go to level 2 and 3 and it would have cost VM a lot more and it would have taken a lot more time and a lot more resource from [us] or whoever.* AutoEngineer Business Unit Director

As this quote indicates product or part criticality, products or parts involving a relatively 'high level' of technical specification at the expense of cost, may favour network intervention to safeguard against potential critical problems, such as safety risks. As there is increasingly a need for innovating companies to control the nature of the parts and technologies that enter their offerings, and the processes used to develop and produce these, there is a significant incentive for intervention. Hence, the need to obtain a high level of control may not only be a regulatory but also an ethical and environmental requirement (Smart, 1992).

8.5.5. Synopsis of Situational Factors

Table 26 summarises the situational, or contingent, factors that appear to influence the three potential strategies of the access strategy, dissemination strategy, and intervention strategy. The findings indicate that the application of the strategies may not be mutually exclusive. Rather, the indications are that they may co-exist within innovation projects.

Table 26. Conditions of Network Co-ordination Strategies

	Access Strategy	Dissemination Strategy	Intervention Strategy
Power	Actor requires limited network power/influence	Actor requires some network power/influence	Actor requires high degree of network power/influence
Supplier Competence Trust	Actor has high level of competence trust in supplier	Actor has some competence trust in supplier	Actor has limited competence trust in supplier
Product Architecture	Integral or modular product/component architecture	Integral or modular product/component architecture	Modular product/component architecture
Product or Part Criticality	Product/part uncritical	Product/part critical	Product/part critical

Thus, the findings from the thesis indicate that the network co-ordination strategies of dissemination (in explicit form) and intervention may be more likely to be conducted if the focal firm has a high degree of network power and influence, limited trust in the competencies of other actors, modular product architectures, and highly specified products or components. The indication from this inquiry is that such focal actors may seek to exert their control over the network by direct intervention or explicitly disseminating, for example, their design specifications and preferences; they may also seek to negotiate directly through such network co-ordination. If these factors are not present, the findings indicate that an access strategy of relying on other actors to control the innovation process may be more likely.

8.6. Situations of Network Constraints on Conduct of Collaboration Activities

The previous sections have revealed how different forms of dependency, including network intervention which may constitute a network constraint, appeared to affect collaboration activities. The final research question addresses the following issue: in which situations is the conduct of collaboration activities most likely to be constrained by the network?

The discussion of different types of dependency effects on collaboration activities highlighted how innovation projects, which spanned international boundaries, appeared to be susceptible to administrative and logistical dependencies. For example, the cases that involved joint venture-based foreign direct investments in production capabilities showed how it became more difficult for the focal companies to control the process as a result of administrative dependencies. Problems of finalising and formalising joint venture agreements constituted one such administrative constraint. As discussed earlier, this indicated that the more international or global an innovation project the more problematic it was to control the innovation process due to administrative dependencies. As this concurs with Håkansson's finding on administrative dependency (1987), it seems that there is some evidence to suggest that the international and global dimension of innovation projects is one critical situational factor.

The link between network co-ordination and network constraints indicates that the factors, which appeared to influence whether companies would be in a position to adopt an intervention, a dissemination, or an access strategy, may also have a bearing on the situations in which the conduct of collaboration activities is most likely to be constrained by the network. Therefore, if a focal actor were interacting with other actors that possessed a high degree of network power and influence, limited trust in the competencies of other actors, modular product architectures, and highly specified products or components, the indication from the research is that such focal actors may have less control over their own activities during innovation projects. The case in which the focal firm, EuroPart, had to cope with those factors provided an illustration of how severe those constraints can be.

The other form of network constraint, risk of dissipation of knowledge to third parties, was seen as a necessary evil across the cases and thus carefully managed. Unlike the biotechnology and pharmaceutical cases in the exploratory mini-survey, all four in-depth case studies involved innovations that occurred within rather weak appropriability regimes (Teece, 1986; 1998). Some of the projects relied at least partly on protecting new technology through patents, however, none of the innovations would be easy to protect purely by legal mechanisms. Whereas several respondents across the cases emphasised the importance of obtaining patents these would most likely be relatively easy to 'invent around'. The exception to this scenario might be the case of the interception gateway project where the technological knowledge appeared to be of a predominantly tacit nature and highly context specific (Peteraf, 1990; Winter, 1987); hence they might be characterised by causal ambiguity (Barney, 1991). This may explain why the technology supplier Securicom seemed confident that it would be very problematic for competitors to replicate the technology. The limitation of the intellectual property regimes governing the two sectors of the case studies elucidates the motivations for actors in the Asian car development project to be so highly concerned about confidentiality, as once launched the car might simply be reverse-engineered and the nature of the material technology unveiled. In fact, the degree of competition in both the automotive and telecommunications industries is so high that it may be reasonable to assume that imitators would overcome many isolating mechanisms (Rumelt, 1987). This assumption would appear to be supported by the findings by Mansfield *et al* (1981) and Mansfield (1985) regarding the speed of imitation across industries. So it was not surprising that respondents tended to exhibit a great deal of awareness of the need to be vigilant in protecting sensitive knowledge – an issue that also made it critical for the researcher to assure and respect confidentiality in a similar manner to other collaboration parties.

Within each case the level of trust in individual relationships was a key explanatory factor in the extent to which risk of dissipation of knowledge posed a problem. Trust was clearly regarded by respondents as a pre-requisite to collaboration. This observation is consistent with the findings of Sako (1992), who argued that goodwill and competence trust become more important than contractual trust as relationships grow over time. Nevertheless, most of the companies involved insisted on supporting intangible trust by tangible non-disclosure agreements. Such formal agreements, however, would only be undertaken with trusted parties, although different levels of trust (goodwill and competence) appeared to influence the level of collaboration. An example of this was TelePart's inability to assume the status of 'strategic partner' with its major customer, which was partly because TelePart had not performed well enough to assume the 'strategic partner' status. To put it more succinctly, it had not gained sufficient competence trust with the customer.

Thus, the main contingent factors for administrative dependency effects correspond to the factors highlighted in Table 25. In addition, international innovation projects appear to be particularly prone to administrative dependency problems. The factors that appear to influence the risk of dissipation implied by networks are primarily goodwill trust and, in some cases, the existence of mechanisms for formalising the level of trust in relationships, such as non-disclosure agreements. In concurrence with the literature the findings support the proposition put forward by e.g. Sako (1992) that formal arrangements are rarely sufficient for establishing the trust required for preventing leakage of knowledge through network connections.

8.7. Conceptual Lessons

This section outlines some of the main lessons gained from the inquiry into the management of collaborative innovative in networks. It focuses on lessons regarding the conceptual structure, firstly considering network effects and secondly the set of collaboration activities.

8.7.1. Network Effects

Network as enabler

The case studies examined two ways in which networks may enable activities: the access strategy, and network co-ordination strategies, the latter including dissemination and intervention. The concept of dissemination, as identified in the literature, implied that the customer explicitly instruct its suppliers to forward its policies, preferences, and protocols to sub-suppliers (Lamming *et al*, 2000b; Lamming 1996). However, the dissemination strategy rarely proved to be conducted as such. It more often took the form of an attitude of 'leaving it to the suppliers'. When no attempts to co-ordinate activities were recorded it was interpreted as signifying that companies employed an implicit dissemination strategy. However, this could be problematic to interpret as a form of network co-ordination.

Another lesson from the case studies was that 'dissemination' was easier to relate to some activities, such as communicating, than others. For example, it was problematic to discuss 'dissemination' in the context of timing. 'Delegation' might have been a better, and perhaps a more accurate, characterisation. However, a more serious problem with the dissemination strategy was that in its implicit form it was hard to separate from what had been conceptualised as a network access strategy, as this effectively relied on a similar strategy of, implicit, delegation. It was discussed in section 8.1 that the understanding and indeed conceptualisation of this concept gradually evolved during the literature review and the empirical data collection. During this learning process the notion of an access 'strategy' became increasingly tentative. In many ways, it simply seemed to describe a basic characteristic of networks and the network function (Håkansson and Snehota, 1995), that is to connect actors through common network connections, and thereby provide a means of access. Nevertheless, this phenomenon did not appear to relate to all collaboration activities and was therefore included as part of the conceptual structure as it still seemed to impact on particular activities. Interesting examples of what could be interpreted as an access strategy also emerged, such as when a focal company consulted its customer about its views of a sub-supplier. More research may need to be conducted to further conceptualise such behaviour.

Network as constraint

'Dependency' and 'risk of dissipation of knowledge to third parties' constituted the two forms of network constraints that had been conceptualised. The case studies focused on three forms of dependency, namely administrative/logistical, technical/technological, and path dependency. Administrative/logistical dependency captured a range of dependency effects, including network intervention by 'other' actors, hence representing the logistical aspect. The case studies revealed that administrative dependencies were often of a legal and commercial nature, for example, in connection with the formalisation of contractual agreements. Such administrative dependencies were particularly evident in the cases featuring complex international joint ventures, which necessitated contractual agreements. As a sub-set of administrative/logistical dependency it may therefore be possible to distinguish between network intervention, legal and commercial dependencies; the latter may be equivalent to what Cousins terms 'economic dependency' (2002). Technological dependencies were also evident across several cases; the concept of technological (rather than technical) dependency seemed to capture dependencies related not only to physical artefacts but also, and perhaps more significantly, intangible knowledge. Path dependencies were apparent across all cases; however, the main lesson on this form of dependency was its dual impact as an enabler as well as a constraint. Interestingly, the research by Håkansson and Waluszewski, 2002), based on a case study of IKEA and its attempts to introduce green catalogue paper, found a similar dual role of path dependence. One lesson regarding path dependency in this thesis concerned the distinction between *path* dependency and *past* dependency: the former was reported in this research when there was an influence of history on activities; this may arguably be conceived of as past dependence rather than path dependence (Araujo and Harrison, 2002). Furthermore, the presence of a historical impact was recorded as a positive path dependency effect, although a negative history was construed as negative path dependency, whereas a positive history was construed as positive path dependency. This problem may constitute a limitation of the findings in relation to path dependence, although as a finding in itself it shows the complex dual role of path dependence as facilitator and constraint of innovation.

The problem of risks of dissipation of knowledge to third parties through network interconnections was constructed as the other form of network constraint. This risk was seen as important across the cases and affected a number of activities, however, most respondents did not perceive it as a problem that could not be managed. Thus, unlike network dependency constraints the risk of dissipation of knowledge to third parties did not appear to be a problem that was regarded as hard to control.

8.7.2. Collaboration Activities

Uniting

The concept of 'uniting' was constructed as an alternative to, for example, supplier or customer selection. It was deliberately named to reflect the interactive nature of industrial customer-supplier relationships. The findings from the cases suggest that although the process in many relationships was very customer-led it was also interactive as suppliers actively sought to become selected. Customer respondents often initially found it difficult to relate to the concept, as they perceived it as one of supplier assessment and selection, or 'nomination'. However, once the meaning of the concept had been explained it was generally seen as a useful construct.

The main pitfall in relation to the concept of uniting is that the term 'uniting' to some people primarily would imply uniting of several actors and thus a network level concept. As a consequence there is a tautological risk of implying that 'uniting of several network actors can be enabled by network co-ordination'. The logic of the conceptual framework is that uniting is a firm-specific relationship-orientated activity, which can be extended into the network by means of network enabling strategies, such as network co-ordination. On that assumption it is believed that the potential tautological problem is reduced.

Timing

The issue of timing was considered to include the problem of early, or more accurately timely, supplier involvement. The companies included in the cases generally seemed to realise the importance of early involvement, but many were struggling to actually implement the practice. Significantly, the notion of 'early' was often fundamentally a question of whether or not supplier involvement in the technical specification process was feasible.

The findings from some of the cases, but most notably the base station equipment development project, indicated the limitations of adopting the individual development project as the unit of analysis, as suppliers (in that case TelePart) may have long term R&D involvement with their major customers. Such R&D involvement may concern technological development and innovation, which span several individual product development projects, or technology development *programmes*. Therefore, albeit a supplier may be involved relatively late in an individual product development project it may have longer term involvement in technology development programmes (Møller, 2002), which gives it visibility of potential product applications prior to entering any specific project. Nevertheless such long-term involvement does not appear to offset the problems of lack of early involvement in specific product application projects. As an overall observation however, the issue of early supplier involvement is still difficult to capture without some understanding of extra-project activities. This may be an important lesson regarding unit of analysis and has also been discussed by Wynstra (1998).

Mobilising

The construct of mobilising covered motivational issues, including risk and reward sharing, and development of 'ground rules'. Risk and reward sharing did appear to be a core element of mobilising, and as the following quote illustrates, sometimes viewed as a differentiator between different types of relationships:

> *....we don't use the word 'partner' with [TelePart], they are a 'strategic sub contractor'.... at [TM] we are quite strong on that differentiation.... A partner is someone who is actually sharing with us in terms of risk and reward so they really are very close to [TM] ....[TelePart] are more 'sub contractors' so it's a little bit one step removed.* (TM)

The development of ground rules was generally recognised by respondents as being of equal importance, even if the notion of 'ground rules' sometimes had to be exemplified.

One problem with the concept was that although the aspects investigated as part of mobilising could all be related to mobilising in one way or another, mobilising was arguably an 'umbrella' for a set of sub-activities; it was difficult to capture these rather divergent issues through one construct. A division into two activities might be one viable solution to this problem.

Communicating

Communicating was constructed as a two-way concept, encompassing informing as well as listening and absorbing information and knowledge. The case studies supported the need to view this as an interactive process; it is doubtful that *informing* would have generated the same insights.

Following the pilot case study, *communicating* was developed as an inclusive activity that included the exchange of knowledge in addition to information. It was decided to amalgamate two previously separate activities into one to avoid the overlap in discussions that had occurred during the pilot case. Nevertheless, the focus of discussions during interviews for the three subsequent case studies was largely on exchange of information and knowledge that can be categorised as predominantly explicit. Exchanges of knowledge of a more tacit nature were rarely captured. The inclusion of different forms of knowledge, including tacit (e.g. Nonaka and Takeuchi, 1995) and thus more critical aspects of knowledge is a challenge for future research.

Exchanging human resources

Overall, there was very limited evidence of activities that could be classified as 'human resource exchange'. Partly this could be explained by the lack of familiarity of such activity amongst the respondents. However, the nature of the focal companies and the projects studied were both likely factors, which could explain the apparent lack of this activity. Certainly, the case of the fuel tank development project illustrated this point, as it was one of the joint venture partners (which had founded EuroPart) and its subsidiary in Japan that had been the main customer interface rather than the predominantly manufacturing-focused EuroPart subsidiary. Therefore, the choice of focal company, and in the fuel tank case a limited travel budget, may explain the apparent visibility of human resource exchange identified across the four case studies.

Synchronising

The operationalisation of the concept of synchronising included both short-term project management synchronisation of, for example, milestones, and long-term strategic alignment. This meant that the former was closely related to the issue of timing and sometimes difficult to differentiate. Long-term strategic alignment was regarded as a core ingredient of highly collaborative relationships across several cases, for example, in the case of the relationship between TM and TelePart. As a long-term management problem, however, it did not relate specifically to individual projects. As a unit of analysis, a project therefore did not capture such long-term synchronisation and adaptation, requiring discussion of extra-project activity.

Problem Solving

Problem solving was included as an activity following the pilot case study. It subsequently also found support in the literature (e.g. Lamming, 1993; 1996; Womack *et al*, 1990; Naudé and Buttle, 2000). The cases supported the suggestion in the literature that a joint approach to problem solving focusing on identification and elimination of causes, rather than symptoms of problems, is a more collaborative approach than one that is based upon the blaming of other parties when problems surface. The majority of respondents stated an intention to seek out root causes rather than apportion blame, although one has to question the universal reliability of such statements, as it may not be uncommon for people to believe in the concept but at the same time in reality to behave in an entirely different manner. In other words, there may be an element of post-rationalisation.

Overall, as discussed in Chapter 9, it may be useful for future research to build on the conceptual lessons from this inquiry and refine the conceptual structure accordingly. One possible development would be to attempt to conceptualise the set of collaboration activities at three different levels based on the framework shown in Figure 10 (Håkansson and Snehota, 1995). This remains, however, an avenue of future research.

8.8. Conclusions

It has been discussed how different forms of network enabler and constraint appeared to influence collaboration activities. Table 27 presents an overview of the different forms of network effect on each of the seven collaboration activities.

Table 27. Relative Importance of Network Effects on Collaboration Activities

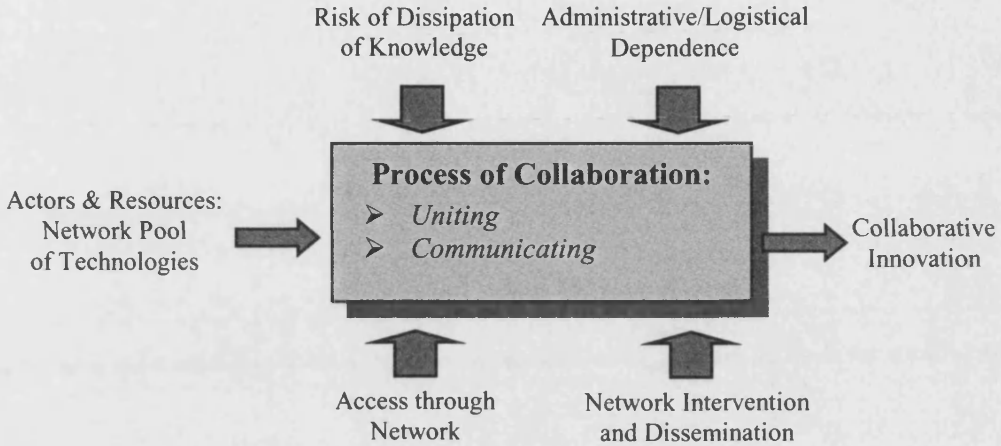
Activity	Network as Enabler		Network as Constraint	
	Access	Co-ordination	Dependency	Risk of Dissipation
Uniting	Yes	Yes	Yes	Yes
Mobilising	No	Yes	Yes	No
Synchronising	No	No	Yes	No
Communicating	Yes	Yes	Yes	Yes
Problem Solving	No	No	Yes	No
Exchanging Human Resources[x]	No	No	No	Possibly
Timing	No	No	Yes	No

[x]: Limited empirical evidence

Table 27 shows that the findings of the thesis indicated that two activities in particular stood out as being most strongly affected by both positive enabling network effects and negative constraining network effects. These were uniting and communicating. Other activities appeared to be less strongly affected. Synchronising, problem solving and timing appeared to be affected by different forms of dependency, most notably administrative and technological dependencies, but not universally by all network effects. Exchanging human resources seemed to be neither enabled nor constrained in any significant way by any forms of network effects, except possibly risks of dissipation of knowledge. However, as will be discussed in Section 8.8.2, the evidence of this activity was very limited in the case studies, so this finding may be less reliable. Indeed the link between this activity and communicating may indicate that network effects could have impacted upon it.

The findings showed the extent to which specific collaboration activities might be affected by networks and in which ways such effects could manifest themselves. In particular, the findings provided early indications that two of the most critical collaboration activities, in which companies engaged when seeking to manage product innovation projects, more than any other activities seemed to be enabled as well as constrained by networks: uniting and communicating. Hence, whereas networks on the one hand provided the lifeline for the conduct of these two activities, the full management and control of these two activities was highly dependent on the network activities and strategies of other network actors. Although most other collaboration activities also appeared to be affected by networks, the effects seemed to be relatively less common. Figure 31 illustrates the main network effects on collaboration activities.

Figure 31. Main Network Effects on Collaboration Activities



Turning the attention to the conceptualisation of the network effects, the analysis testified not only to the relative importance of some effects, but also to possible inter-connections between enabling and constraining effects. Table 28 provides an overview of these effects on the collaboration activities.

Table 28. Conceptualising Network Constraints and Enablers on Collaborative Innovation

Network as Constraint	Network as Enabler
Increased Dependency: Technological Dependence: May affect uniting, synchronising, timing, and problem solving Administrative/Logistical Dependence: May affect uniting, mobilising, timing, communicating. Possibly also synchronising and problem solving Path Dependence: May affect communicating and problem solving	Network Co-ordination Strategies: Intervention and Dissemination May affect uniting, communicating, mobilising
Risk of Dissipation of Knowledge: May affect uniting, communicating, mobilising	Access Strategy: May affect uniting and communicating

As Table 28 illustrates, the two forms of network constraints and enablers appeared to constitute related effects. As explained in Sections 3.4.2 and 4.3.2, the two columns of the table were not designed to accurately portray and conceptualise the mirror, negative and positive, sides of network effects. The conceptual structure did not seek to encapsulate the corresponding network enabling effects of the different forms of dependency effects and 'risk of dissipation of knowledge' and *vice versa*. Nevertheless, the findings unveiled that administrative/logistical dependence and network co-ordination to a large extent represented two different sides of the same coin. This was also evident in their apparent impacts on collaboration activities, specifically those of uniting, communicating, and mobilising. The fact that administrative/logistical dependencies seemed to impact upon more activities than network co-ordination may be explained by the wider spectrum of effects captured by the former.

Similarly, the opposite network effects of 'risk of dissipation of knowledge' and 'network access strategy' appeared to influence much the same activities, specifically uniting and communicating. This may be logically explained by the emergent realisation on behalf of the researcher that these two constructs both revolved around the problem of accessing networks. In other words, the bridges or conduits provided by inter-connected relationships may not only be used to enable activities, but also constituted a route to the loss of knowledge.

Overall, the findings revealed how one actor's attempts to use the network as an enabler through the co-ordination strategies of dissemination and intervention was likely to present a constraint in the form of administrative dependency to other actors in the network. Companies try to manage within the network whilst at the same time coping with the attempts of other companies to manage within the very same network. The cases unveiled that the potentially destructive strategy, at least for some actors in the network, of intervention could also be applied in a more supportive and collaborative manner. The extent to which the intervention strategy was viable, however, was not merely a question of power and influence. The findings indicated that the factors of modularity of product and network architecture, and commercial and technological criticality also favoured intervention.

In addition to the conceptual lessons implied in this concluding section the final part of the chapter addressed the main lessons from the empirical enquiry. This was divided into network effects and collaboration activities. The main lesson on positive network effects included the difficulties in distinguishing between the access strategy and network co-ordination strategies, particularly in relation to dissemination strategies being conducted in an implicit form as a 'leave it to suppliers' attitude. On negative network effects a set of different forms of administrative/logistical dependencies emerged: network intervention performed by other actors (logistical), and legal and commercial dependencies. Path dependency seemed to incorporate a dual effect as both an enabler and constraint of collaboration activities. Risks of dissipation of knowledge to third parties via network connections, although affecting a variety of activities, did not appear to be a problem that respondents viewed as problematic to control; it was generally managed by ensuring a high degree of trust in collaborative relationships.

Finally, a number of lessons were gained in relation to the collaboration activities. Most significantly, it was pointed out that uniting, although constructed as a firm-specific relationship-orientated activity, could be interpreted as a network-level activity. Mobilising emerged as an 'umbrella' construct, encompassing a variety of important sub-activities, which however emerged as being conceptually different; the development of ground rules and risk and reward sharing did not always appear to be logically inter-linked. Both timing and synchronising emerged as activities that not only concerned individual product development projects but also spanned across individual projects into long-term technology programmes. This indicated the limitations of adopting projects as the main unit of analysis. Knowledge exchange, although designed to form part of communicating, was not adequately captured. The cause of this problem was likely to have been the lack of specific questions to tease out exchange of knowledge as opposed to information. The inclusion of different forms of knowledge, including for example explicit and tacit knowledge, is a challenge for future research. There was little evidence, or at least visibility, of human resource exchange activity, so limited empirical data on this activity could be collected. However, one reason for the lack of evidence might in some cases be the choice of focal firms and innovation projects. Finally, the danger of post-rationalisation by respondents in relation to problem solving was discussed, although no major conceptual lessons were identified.

CHAPTER NINE: CONCLUSIONS, IMPLICATIONS AND LIMITATIONS

This chapter presents the overall conclusions from the thesis. It begins by drawing the main conclusions based upon the aim and objectives that were set out in Chapter One. Thereafter, the contributions and limitations of the thesis are discussed. A discussion of managerial implications follows and leads to an outline of future avenues of research. The chapter concludes with an epilogue.

9.1. Conclusions

The thesis set out to examine how innovating companies deploy the resources and technologies available within their network whilst at the same time coping with the problem of loss of control of knowledge and technologies. A set of more specific objectives was developed to address the overall aim. This section presents the conclusions on each of these objectives.

9.1.1. Objective 1:

- *to identify a set of activities that companies apply during technological innovation to draw upon individual dyadic relationships and gain access to resources and technologies available in the wider network*

The first objective was addressed through a review of the literature combined with exploratory empirical investigation. The preliminary literature review revealed a variety of activities and resulted in an initial set of activities: - identifying/selecting, timing, mobilising, informing, synchronising, assigning human resources, and co-ordinating.

The initial set of activities was used for the exploratory mini-survey and refined following further literature review. It was discussed in Chapter Five how this was an abductive process of simultaneous literature search and empirical investigation, rather than a linear deductive process. Following this process, 'identifying/selecting' was replaced with 'uniting' as the exploratory mini-survey, together with further literature review, indicated that actors in some cases were not simply identifying and selecting other actors in a rational fashion; in some cases they were at least as much subjected to *being* identified and selected. The IMP *interaction* model was instrumental in revising the collaboration activities and adopted as the major perspective in this thesis (e.g. Håkansson, 1982; Ford, 1990). The two activities of 'informing' and 'assigning human resources' were substituted with, respectively, 'communicating' and 'exchanging human resources' for the same reason. 'Co-ordinating' was removed after the exploratory mini-survey as it emerged as an element of all activities, namely that all activities are somehow co-ordinated within the network. It was instead included as part of the enabling 'network effects' and so became redundant as a separate activity.

The revised set of collaboration activities following the exploratory mini-survey and further literature review was: - uniting, mobilising, synchronising, communicating, exchanging knowledge, exchanging human resources and timing. This set of activities was based on an interaction perspective, which emerged as increasingly important for understanding how companies manage technological innovation in networks (e.g. Håkansson, 1987; Ford and Saren, 2001). The interaction perspective also made it realistic to assume that the same activities would apply for the management of upstream as well as downstream relationships. A company's relationships with its suppliers and customers essentially concern the same forms of relationship, customer-supplier relationships, only viewed from different perspectives. The activities involved in the management of supplier relationships are thus logically similar to those involved in customer relationships.

A final iteration of the set of collaboration activities took place. The pilot case study, the first of the four in-depth case studies, included knowledge exchange as a separate activity from communicating. However, these two activities proved to be overlapping and thus difficult to distinguish as separate. Knowledge exchange was replaced with problem solving, which emerged as an important ingredient of collaborative innovation in the pilot case and subsequently also found support in the literature (e.g. Lamming, 1996; Takeishi, 2001; Naudé and Buttle, 2000).

It was recognised that some collaboration activities were more generic than others. Principally, timing and communicating were seen as underlying activities given that there may be timing and communication elements of all the other activities (see Figure 15). For example, it can be argued that the reason why companies should wish to engage in exchanging human resources would be to facilitate communication.

The review of different bodies of literature indicated that each of the collaboration activities is critical to the management of collaborative innovation (see Table 8). The empirical investigation in this thesis did not set out to prove or disprove the level of criticality of individual activities. The four in-depth case studies demonstrated that the final set of activities was useful for describing and understanding key processes of collaborative innovation management with specific respect to product development projects. Empirical analysis based around the set of activities revealed that each of the activities took place between customers and suppliers involved in product development projects, although the examples of one activity, 'exchanging human resources', were limited for a number of reasons. The lessons of the activities were discussed in Section 8.7.2 and we return to these towards the end of this chapter when discussing the limitations of the study. Table 29 provides a brief definition of each activity:

Table 29. Collaboration Activity Set Revisited

Activity	Definition
Uniting	The process of identifying actors, including selection criteria – or being identified/selected
Mobilising	The process of motivating actors to commit to project, including establishing ground rules and objectives and arranging sharing of risks and benefits
Synchronising	The process of mutually adapting activities and resources, including development procedures; aligning objectives and technology roadmaps
Communicating	The process of exchanging e.g. design ideas, concepts, technical specifications, policies, procedures and performance information
Problem Solving	The process of resolving e.g. technical or manufacturing/supply problems
Exchanging Human Resources	The process of allocating (on long-term mutual basis) staff to development projects e.g. resident design engineers
Timing	The process of deciding the moment or stage of involving actors in the project

The activities shown in Table 29 represented different ways in which individual companies managed product innovation projects vis-à-vis other actors. They were thus firm-specific and relationship-orientated. The problem of how they might be extended into the wider network surrounding companies was the second objective of the thesis. This is addressed in the following section.

9.1.2. Objective 2:

- *to examine how companies draw on networks when managing the identified set of activities*

The second objective of the thesis concerned how companies make use of networks when managing collaboration activities during technological innovation. This implied that it was about the positive implications of networks and thus involved generating insights into how the set of activities identified was managed beyond the dyadic relationship level. The second objective was initially investigated through the literature and subsequently empirically investigated through initially the exploratory mini-survey and then the four in-depth cases.

Drawing on the complementary perspectives of network theory, supply chain management and lean supply, two main ways in which companies may use networks to enable collaborative innovation activities were conceptualised. The first was described as an 'access strategy'; this sought to capture the use of one relationship to gain access to other indirect relationships and was perceived as a predominantly informal use of networks, to some extent implying a 'conceding' style (see Ford *et al*, 2003). The second enabler was conceptualised in the form of two 'network co-ordination strategies': network intervention and network dissemination. They were formulated as means to capture attempts to co-ordinate or convene actors, resources and activities in the wider network and were seen as potentially more explicit, assertive and coercive attempts by companies that aim to capitalise on a wider part of the network in which they operate.

The empirical research indicated that companies often used the access strategy to enable two collaboration activities within networks: uniting and communication. The case studies showed how companies appeared to use the access strategy to enable uniting with network actors. The case of the fuel tank development project specifically demonstrated how one supplier to the focal company, EuroPart, had been assigned an access role by the end customer, a Japanese vehicle assembler. Similarly, companies used the access strategy to enable communicating within networks. This was most evident in the Asian car development project and the fuel tank development project, most notably in relation to obtaining design change information. The companies involved in the case studies did not appear to use the access strategy to enable the remaining collaboration activities. Whereas this should not be taken as an indication that the remaining activities were not conducted throughout the network, it implied that individual companies did not seem to take advantage of networks through what had been conceptualised in this thesis as an 'access strategy' to the same extent to enable those activities. This finding concurred with a number of related findings by other researchers (e.g. Håkansson and Eriksson, 1993; Bower, 1993) although the findings of this thesis pointed specifically to how this affected certain collaboration activities during product innovation activity. The lessons regarding the concept of the 'access strategy', however, were discussed; these will be further highlighted in section 9.3: Limitations.

There were several examples from across all four case studies of how companies sought to enable uniting and communicating by means of network co-ordination strategies. In the case of uniting, some of the focal companies, and more often their large customers, sought to intervene in sub-supplier selection. Similarly, companies in the cases sought to enable communicating through network co-ordination strategies e.g. by communicating design changes and terms and conditions, directly with indirect suppliers. Finally, there was evidence of companies using network co-ordination strategies to enable mobilising, for example, when companies endeavoured to drive delivery targets by liaising directly with sub-suppliers.

The findings indicated that network co-ordination strategies might be more likely to be conducted by focal firms if the following conditions were present: a) if the focal firm had a high degree of network power and influence; b) if the focal firm had limited trust in the competencies of other actors; c) if the product being developed had a modular product architectures; d) if the product or component being developed was critical e.g. in terms of safety requirements. If these factors were not present, the findings indicated that the access strategy of relying on other actors to manage the innovation process could be more likely. Some literature appeared to support this observation (e.g. Gadde and Jellbo, 2001; Araujo, 2003) but further empirical testing, however, is required to validate this exploratory finding.

9.1.3. Objective 3:

- *to examine the extent to which networks pose a constraint on the conduct of the identified set of activities*

The third objective concerned how networks might constrain the conduct of collaboration activities during technological innovation. Hence, it concerned the negative implications of networks. Like the second objective, the third objective was initially examined through the literature and subsequently empirically investigated through the exploratory mini-survey and then the four in-depth cases.

The literature revealed that innovation activities were constrained as a result of operating in networks. An interaction and network perspective implied that individual actors, or companies, have to cope with the behaviour and actions of other network actors. Such a view contrasted with the assumption present in many modern strategic management theories, including the resource-based view (e.g. Wernerfeldt, 1984; Barney, 1991), which stressed the importance of internal development and nurture of distinctive resources and competencies and the need to protect these from other organisations (e.g. Rumelt, 1987). In contrast, the network perspective assumed that resources, competencies and technologies are developed and deployed through networks (Ford *et al*, 2003). Companies are relying on external companies to develop, manage and supply technology, which increasingly comes in bundles that form part of complex system offerings (Granstrand *et al*, 1997; Gadde and Jellbo, 2002).

Two main forms of network constraint were discussed. The first concerned 'dependency effects': when companies collaborate with external companies they become dependent upon these. Five main forms of dependence were identified and discussed: - technical or technological, administrative or logistic, path, knowledge, and social dependencies. It was decided to focus on the first three of those, viewing knowledge dependency as an integral part of technological dependency. The second was conceptualised as 'risk of dissipation of knowledge': knowledge may dissipate through network inter-connections to, for example, competitors. As companies increasingly compete on unique knowledge and competencies such dissipation may present a serious risk.

The empirical findings demonstrated how the risk of dissipation of valuable knowledge to third parties constrained the activity of communicating. Other collaboration activities, however, did not appear to be constrained by this risk. The cases revealed how the risk of dissipation of knowledge was often seen as real, but they also suggested that companies have begun to develop effective ways to either avoid or manage the problem. Many companies simply communicated on a 'need to know basis' with any actors not considered key collaboration allies. Indeed, a metaphorical 'Chinese wall' would often be established to segment information and knowledge between essential and non-essential relationships and thereby prevent knowledge leakage. The findings on this management problem concurred with much existing research, including e.g. Bower and Whittaker (1993), Sako (1992), Kale *et al* (2000) and Dyer and Nobeoka (2000). Like, for example, Dyer and Nobeoka's (*ibid.*) research on Toyota's encouragement of knowledge sharing within its network, the cases in this thesis indicated that the risk of dissipation of knowledge was seen as a necessary evil; it had to be managed through trust and knowledge segregation rather than purely formal contractual arrangements.

The empirical findings indicated that all activities except from human resource exchange (where the findings were limited) were constrained by different forms of dependency effect. This meant that as a result of network dependency constraints, the management of the set of collaboration activities was at least partly outside the control of individual focal actors; these were dependent on how other network actors conducted collaboration activities in their parts of the wider network.

The most striking finding was the duality of network effects: the concept of network co-ordination was constructed as a network enabler, but emerged from the findings as a simultaneous network enabler and constraint, depending on the perspective. The most interesting example related to network intervention; the cases included several examples of how intervention conducted by one network actor affected the ability of focal companies to control their own collaboration activities. Therefore, intervention performed by one network actor constituted a form of administrative or logistical dependency on other network actors.

Path dependency was manifested either in the form of a poor record of accomplishment inhibiting future involvement or through the difficulties of submitting new suppliers to extensive qualification processes. Once suppliers had undergone qualification processes some customers were unwilling to unite with new suppliers. However, an emergent conceptual finding in relation to path dependency was that although it was conceptualised as a network constraint it, also, emerged as a simultaneous enabler and constraint of several activities; these included uniting, communicating and problem solving. For example, a positive record of accomplishment was an enabling factor in the ability of suppliers to become involved in new projects, indeed in some cases this was a precondition as this had generated trust and thus reduced the risk often associated with involving new unknown suppliers. This dual role of path dependency had recently also been discussed by Håkansson and Waluszewski (2002). Thus, path dependence was found to contribute positively to technological development.

Finally, the problem of technological dependency was investigated. The literature indicated that the problem of technological dependency was closely related to the question of how companies manage the make-or-buy (or develop-or-buy) decision. As companies are increasingly out-sourcing what they consider to be non-core activities and technologies, they are likely to become more dependent on technologies available through networks. From this perspective, several collaboration activities were constrained by technological dependency, including uniting, timing, synchronising and problem solving.

The final research question turned out to be closely related to the question concerning the appropriateness of network co-ordination strategies, as one network actor's co-ordination attempts turned out to present a problem of administrative or logistic dependency for other network actors. Therefore, in the cases in which network intervention strategies were applied extensively, such as the case of the fuel tank project, some network actors had to cope with interventions by other actors. Such intervention affected their ability to control collaboration activities within the networks. The factors that seemed to explain such network co-ordination patterns - power, competence trust, product architecture and product or part criticality - therefore also appeared to explain when activities were likely to be constrained as a result of administrative dependency. Furthermore, administrative and logistical dependencies were most evident in cases that spanned international boundaries, for example, involving joint venture-based foreign direct production capability investments. This was notably the case in the Asian car development project, but also in the fuel tank development project. This indicated that the more international or global an innovation

project the more problematic it may be to control the innovation process due to administrative dependencies. This finding was consistent with Håkansson's (1987) suggestion that administrative dependency may be becoming more important due to increasing internationalisation. The fact that administrative/logistical dependencies seemed to impact upon more activities than network co-ordination may be explained by the wider spectrum of effects captured by the former.
The main factors that appeared to influence the risk of dissipation implied by networks were primarily the level of goodwill trust (Sako, 1992). In concurrence with the literature (*ibid.*) the findings supported the proposition that formal arrangements are rarely sufficient for establishing the trust required for preventing leakage of knowledge through network connections.

9.2. Contributions

Overall, the contributions of this thesis revolve around the understanding of how networks affect technological innovation processes. Specifically, the contributions concern the paradox of how companies engaged in new product development projects, on the one hand use networks to their advantage, but on the other hand are constrained in their ability to control the innovation process.

One contribution is the set of collaboration activities. Previous scholars have sought to develop similar sets of activities for managing, for example, supplier (or purchasing) involvement in product development (e.g. Håkansson and Eriksson, 1993; Wynstra, 1998). However, the set of activities developed in this thesis is arguably of a more interactive nature than previous efforts.

Perhaps more importantly, the thesis contributes to debate about the extent to which specific collaboration activities may be affected by networks and in which ways such effects may be manifested. In particular, the findings provide early indications that two of the most critical collaboration activities which companies engage in when seeking to manage product innovation projects - uniting and communicating - more than any other activities seem to be enabled as well as constrained by networks. Hence, whereas networks on the one hand provide the lifeline for the conduct of these two activities, the full management and control of these two activities is highly dependent on the network activities and strategies of other network actors. Although most other collaboration activities also appear to be affected by networks, the effects seem to be relatively less comprehensive.

The findings of the thesis indicate that two activities in particular stand out as being most strongly affected by both positive enabling network effects and negative constraining network effects. These are: - uniting and communication. Other activities appear to be less strongly affected. Synchronising, problem solving and timing only appear to be affected by different form of dependency, most notably administrative and technological dependencies. Exchanging human resources neither seem to be enabled nor constrained in any significant way by any forms of network effect, except possibly risks of dissipation of knowledge. However, as discussed in Section 8.8.2, the evidence of this activity is very limited in the case studies, so this finding may be less reliable.

The analysis also indicates possible inter-connections between enabling and constraining effects. Most importantly, administrative/logistical dependence and network co-ordination to a large extent represent two different sides of the same coin. The findings have revealed how one actor's attempts to use the network as an enabler through the co-ordination strategies of dissemination and intervention is likely to present a constraint in the form of administrative dependency to other actors in the network. Companies have to try to effectively network and manage within the network whilst at the same time cope with the attempts of other companies to network and manage in the network. The cases have unveiled that the potentially destructive strategy, at least for some network actors, of intervention can also be applied in a more supportive and collaborative manner. The extent to which the intervention strategy is viable, however, is not merely a question of power and influence. The findings have indicated that the factors of modularity of product and network architecture, and commercial and technological criticality also favour intervention.

9.3. Limitations

The limitations of this study can be divided into those that concern conceptual and/or methodological issues and those that concern the actual findings.

One conceptual limitation concerns the focal firm network perspective adopted in this thesis. This perspective was chosen because of a number of advantages of such a perspective, such as the more immediate, short- and medium-term, managerial consequences of the focal firm network on the focal firm itself i.e. a conceptual reason, and the relative feasibility and practicability of researching non-focal firm networks i.e. a methodological reason. A focal firm network orientation, however, is inevitably limited in its ability to capture the wider consequences of networks. Ford *et al* (2003) argue that a focal firm network perspective ignores potential sources of solutions or pressures that the company faces long-term. The case of the Asian car development project is a case in point: the core material technology was brought in from outside the automotive industry, using boats and bathroom technology, so the focal company, AutoEngineer, would have considered as part of its network picture the suppliers of this technology that were on the border of, or outside, the focal firm network. Wider network analysis could have explored this part of the network, entering an entirely different industry. Another example would be the case of the fuel tank project, which particularly illustrated the problems of intervention strategies. However, this was the problem as predominantly seen from the focal company, EuroPart. The intervenor, the vehicle assembler, was not ignored but was interviewed and its picture of the network explored. However, this data collection primarily focused on its relationships with EuroPart and those relationships that had a more or less direct impact on EuroPart. Consequently, the full complexities and dynamics of the network were only partially uncovered. Whether or not, for example, network intervention was of benefit to the vehicle manufacturer, and potentially therefore to EuroPart and other suppliers in the long-term, remained unexamined.

Another conceptual limitation concerns the heart of the conceptual framework: the set of collaboration activities. Whilst it is believed that this set of activities reflects and captures how companies across industries may involve their suppliers and customers in product innovation projects, the activities remain generic. Therefore, there may be aspects of the activities that are of limited relevance in some industries and/or countries, or there may be essential elements of activities that are missing. It has neither been the purpose of this research to construct and refine a set of comprehensive activities that offers managerial guidance to companies, nor to investigate how the activities may vary across different circumstances. Instead, the activities have served as a substructure for investigating how networks may affect a set of activities, which is likely to be of generic relevance to companies that seek to collaborate within networks for the development of new products and technology.

Another limitation in relation to the conceptual structure pertains to the conceptualisation of network enablers. The findings provided important conceptual lessons on the usefulness and validity of the concepts of the 'access strategy', the 'dissemination strategy', and the 'intervention strategy'. One of the lessons from the cases was that the dissemination strategy often seemed to be practised implicitly as a 'leave it to the suppliers' approach. The evidence regarding this, however, was inconclusive. Furthermore, it made the concept problematic to distinguish from the access strategy. These conceptual problems thus present a limitation of the study.

The main limitation concerning network constraints pertains to the concept of path dependency. Path dependency was reported when there was an influence of history on activities, however as discussed earlier, this may arguably be conceived of as past dependence rather than path dependence. In other words, history matters but events (their sequence and temporal unfolding) may not necessarily follow a particular path or trajectory (Tilly, 1994; Araujo and Harrison, 2002). The interpretation of historical impacts as path dependency effects thus constitutes a limitation of the findings.

Furthermore, the limited investigation of performance effects of activities and network effects constitutes a methodological limitation. Performance questions were included as part of the interviews and the results were documented in Chapter Seven. However, these say little about actual effects on project outcomes. Furthermore, long-term extra-project effects were not investigated. No post-project studies have been carried out, which could have attempted to measure long-term performance effects. It has already been argued, however, that the measurement of such effects would be highly problematic given the difficulty in identifying causality in networks (see Chapter Five).

Another methodological limitation concerns the problems of adopting the individual development project as the unit of analysis. For example, suppliers may have long-term R&D involvement with customers for the purpose of technological development. These are likely to span several individual product development projects. Therefore, albeit a supplier may be involved relatively late in an individual product development project it may have long-term involvement in technology development projects or programmes, which gives it visibility of potential product applications prior to entering any specific project. Hence, the issue of supplier involvement in product development is difficult to capture without some understanding of extra-project activities.

In terms of the actual findings of the inquiry, a limitation concerns the limited number of case studies that have been conducted. As explained in Chapter Five the choice of four case studies conducted across two industries was motivated by a wish to maintain external validity and analytic generalisation in particular. No one of the four cases stood out as being highly unique in any way, although each individual case featured particular themes. Therefore, the external validity provided by four cases constituted a first step towards replication and thus testing of the findings in different contingencies (Tsang and Kwan, 1999). Without further testing, however, the findings cannot in any way be generalised into other contingencies than those examined here. It is also recognised that one of the four cases, the interception gateway project, was limited in scope and scale as it only involved interviews with the focal company and its main supplier in the project. Furthermore, direct comparisons with the three other cases were problematic given the focal company's network position. Unlike the three other focal companies in the other cases, NetCom was an assembler rather than a supplier to assemblers. The advantage of NetCom's different position and thus perspective was that it offered a useful contrast to the three other cases and thus helped to understand and interpret the three 'supplier-focused' cases.

9.4. Managerial Implications

Thus far the thesis has avoided making normative statements concentrating instead on making analytical observations and conclusions. At this stage, however, it is appropriate to try to draw out some of the possible managerial implications of the inquiry.

9.4.1. Interactive Innovation

The first managerial implication is that innovation needs to be understood as something which is generated through interaction with a myriad of actors with different knowledge, capabilities and technologies, of which suppliers and customers are critical sources. Much research has pointed out that customers can provide critical information and feedback about market needs. Similarly, research has identified that suppliers have specialised capabilities and technologies allowing them, potentially, to contribute to improving the value of new offerings being developed and reducing cost and development lead-time. However, the notion of who is the customer and who is the supplier is often blurred: all actors are essentially suppliers and at the same time customers, serving the end market, be it a consumer or industrial market. As a consequence, it is not simply a question of whether or not a company should involve its suppliers and customers in product development. Instead, there is a need for companies to think about how they can *interact* with a host of other actors; this involves responding to the demands of other companies and requesting the involvement of other actors. The case studies included numerous examples of companies that on the one hand complained that their customers failed to involve them properly in product development, and on the other hand struggled to understand that the very same situation often applied in their own supplier relationships.

9.4.2. Appropriate Management of Collaboration Activities

The set of collaboration activities constitutes different ways in which companies can interact with suppliers and customers. Although some activities may arguably be more appropriate in some circumstances than others, the set of activities can potentially be used as a reference list to check, for example, whether some aspects of collaboration are ignored or even managed in a non-collaborative way. Some form of balanced approach may be more likely to generate the desired results, ensuring consistency in the level of involvement of external parties and the right combination of 'carrot and stick'. The process of activity mapping, using the framework provided in Figure 19 as a tool, might be useful to aid such analysis.

Although a managerial implication of this thesis is that interaction and collaboration are critical to managing innovation, it is not a question of either/or. It is unlikely that an undifferentiated approach to relationship management for innovation will be the way to reap the desired outcome. Relationships are heterogeneous and therefore need to be treated individually. A framework for classifying different relationships into common types and managing them accordingly may help companies to ensure the right parties are managed in the appropriate way. Therefore, the management of the set of collaboration activities needs to be geared to the particular characteristics of individual relationships. A number of established portfolio models exists for this purpose, including Clark (1989), Kamath and Liker (1994), and Wynstra and ten Pierick (1999).

9.4.3. Understanding the Conditions that Drive other Network Actors Towards Intervention

Another managerial implication of the research is that although there may be very good reasons for seeking to collaborate with suppliers and customers during technological innovation, companies may be unable to do so because they operate under network constraints. For example, the findings of the thesis indicate that a company may be unable to control its own management of collaboration activities because powerful customers, which do not have sufficient competence trust in its ability to manage the innovation processes within its own supplier relationships, are intervening in its choice of, and communication with, its key suppliers. The findings of the thesis also indicate that a company involved in the development of a critical product or part that has a modular product architecture may be more likely to be subjected to customer network intervention in uniting and communication activities. Conversely, in such situations companies may also wish to intervene themselves in, for example, sub-supplier decisions. Hence, the choices and actions, which individual network actors can take, may be limited in certain circumstances. Consequently they have to cope with the constraints imposed on them by other network actors.

9.4.4. Coping with Network Intervention

One way of coping with situations of excessive customer intervention may be for companies to establish a more viable network position. For example, they may be able to take more control of the system they offer to become full-systems suppliers. This could involve merging with or acquiring other actors in the network to enable companies to provide a full-system offering. For some companies an alternative may be to develop strategic relationships with other companies thus taking charge of their own destiny, but without having to make the capital investments which are difficult and risky for many companies. Finally, in extreme cases the development of new customer relationships may be the only solution to limit over-reliance on powerful intervening customers.

9.5. Future Avenues of Research

This thesis has not attempted to test any pre-defined propositions or hypotheses. It has explored and examined a number of issues of importance to companies involved in technological innovation. The implication of this purpose of the research is that a number of avenues of future research exist. The most important of these are discussed here.

The first avenue of future research would be to build on the conceptual lessons from this inquiry and refine the conceptual structure accordingly. For example, one idea is to conceptualise the set of collaboration activities at three different levels based on the framework shown in Figure 10 (Håkansson and Snehota, 1995). The robustness of the refined structure could then be validated in a set of case studies.

Alternatively, or perhaps subsequently, the conceptual structure could be operationalised and used to formulate a number of propositions. Using a structured questionnaire, which could subsequently be used as an instrument to further validate and test the results on a wider set of contexts, quantitative analysis could confirm, disconfirm or refine the contingent factors that have emerged from this inquiry.

One option would be to identify the relevance of each collaboration activity along a time line, either project-specific or extending beyond individual projects. This would not only help to define the activities even more clearly, but also be a step in the direction towards a more managerially-orientated framework, in a similar manner to, for example, the framework offered by Dowlatshahi (1992) and Calvi (2003).

Finally, an important area of future research relates to the link between product modularization and supply network structures and strategies. Existing research has examined the trends towards modularization across a variety of industries, although predominantly automotive and computers (e.g. Baldwin and Clark, 1997; Langlois and Robertson, 1992; Doran 2003; Sako and Warburton, 1999). However, from a network perspective a number of critical questions remain to be answered, such as:

- How do different product architectures affect supply network architectures and strategies?

- How do modular product architecture strategies devised by OEMs impact on the existing and future requirements for supplier capabilities?

9.6. Epilogue

Life is understood backwards but lived forwards - Søren Aabye Kierkegaard

And so is this thesis. Research is always a learning experience and the complexity of researching networks means that with the benefit of hindsight one sometimes wishes that one had done certain things differently. One of these would have been to refrain from trying to bridge two schools of thought: KISS! (Keep It Simple Stupid).

My attempt to position myself in two complementary but nevertheless in some ways distinctive schools of thought, IMP and 'Supply', over a period of six-seven years has been challenging and at times problematic. The work as a Research Officer within CRiSPS (and subsequently as lecturer in supply management), has revolved around emerging concepts such as supply networks, supply strategy, lean supply, and inter-organisational networking (Project ION). The 'CRiSPS approach' features an operations-based understanding of the *management of* customer-supplier relationships, supply chains and networks; CRiSPS projects often involve the development of methodologies and tools for managerial guidance and are therefore often normative in orientation. In comparison, the IMP approach is concerned with the development of a more comprehensive understanding of the complexities and implications of managing or *coping in* networks. The IMP group has developed a substantial amount of theory in this area and has thereby created the conceptual terminology and language used throughout this thesis.

The interaction between - and bridging of - those two research environments has resulted in a level of learning that would have been hard to gain otherwise. The most evident manifestation of this interaction was the conceptual framework: it was a direct result of combining an operations-based CRiSPS-orientated approach with an IMP model and approach. This ambition leaves two possibilities: researchers from both schools may disapprove of it, or at least one of the schools will be able to understand and appreciate the logic. Hopefully, the latter is the case but that is for the reader to decide.

The discussions have revealed that the development of the thesis has, however, by no means been a smooth process; a researcher in the position of trying to bridge two approaches inevitably feels the scale of the problems of cross-functional working himself and learns to appreciate when respondents explain their cross-functional and cross-organisational problems. Therefore, even if the report documenting this thesis comes across as an ordered and linear process, this is a tremendous simplification of the reality – like the innovation projects that were studied, the process was more often chaotic and confused than linear, sequential and controlled.

Bibliography

Abernathy, W.J. and Utterback, J. (1988) Patterns of industrial innovation. In *Readings in the Management of Innovation*, 2^{nd} ed., Tushman, M. and Moore, W. (eds.). New York, Harper Business.

Achrol R.S. (1991) Evolution of the marketing organisation: new forms for turbulent environments. *Journal of Marketing*, Vol. 55, October, pp. 77-93.

Aldrich, H.E. (1979) *Organisations and Environments*. Englewood Cliffs, NJ: Prentice-Hall.

Ancona, D.G. and Caldwell, D.F. (1990) Beyond boundary spanning: managing external dependence in product development teams. *Journal of High Technology Management Research*, Vol. 1, pp. 119-135.

Andersen, V. and Gamdrup, P. (1990) Forskningsmetoder (Research Methods). In Andersen, H. (ed.) *Videnskabsteori og Metodelære: Introduktion*, pp. 57-78, 3rd ed., Samfundsliteratur, Denmark.

Andersen, D. M. (2001) *Design for Manufacturability: Optimizing Cost, Quality and Time-to-Market*, Cambria, California: CIM-Press, 2^{nd} edition.

Anderson, J.C., Håkansson, H. and Johanson, J. (1994) Dyadic Business Relationships within a Business Network Context. *Journal of Marketing*, Vol. 58, October, pp. 1-15.

Andreasen, M. M. and Hein, L. (1986) *Integrert Produktudvikling* (Integrated Product Development), Universitetsforlaget A/S, Norway.

Araujo, L. and Easton, G. (1996) Networks in socioeconomic systems: a critical review. In Iacobucci, D. (1996) *Networks in Marketing*, Sage: USA.

Araujo, L. and Mouzas, S. (1997) Competition and cooperation in vertical marketing systems. In Gemünden, H-G., Ritter, T. and Walter, A. (eds.), *Relationships and Networks in International Markets*, Elsevier Science Ltd.

Araujo, L, Harrison D, 2002, Path dependence, agency and technological evolution. *Technology Analysis and Strategic Management*, Vol. 14, No. 1, pp 5-19.

Araujo, L. (2003) *Modularisation, operations and supply network strategies.* Presentation at the Centre for Research in Strategic Purchasing and Supply, University of Bath School of Management, UK, 27 November 2002.

Axelsson, B. and Easton, G. (1992) *Industrial Networks: A new View of Reality*, Routledge, London.

Ayer, A. (1968) *The Origins Of Pragmatism*, 1^{st} ed., London, Macmillan.

Bachrach, P. and Baratz, M. (1970) *Power and Poverty, Theory and Practice*, New York, Oxford University Press.

Baldwin, C.Y. and Clark, K.B. (1997) Managing in the Age of Modularity, *Harvard Business Review*, Vol. 75, No 5, 1997, pp. 84-93.

Ballou, R. Gilbert, S. and Mukherjee, A. (2000), New management challenges from supply-chain opportunities. *Industrial Marketing Management*, Vol. 29, Issue 1 (January 2000), pp. 7-18.

Barney, J. (1986) Strategic factor markets: expectations, luck, and business strategy. *Management Science*, Vol. 32, No. 10, pp. 1231-41.

Barney, J. (1991) Firm resources and sustained competitive advantage. *Journal of Management*, Vol. 17, pp. 99-117.

Bessant, J., Caffyn, S., Gilbert, J., Harding, R. and Webb, S. (1994) Rediscovering continuous improvement. *Technovation*, 14 (1), pp. 17-29.

Bessant, J. and Tsekouras G. (2000) Developing learning networks. *AI and Society*.

Bhaskar, R. (1978) *A Realist Theory of Science*, The Harvester Press, Sussex.

Bideault, F. and Butler, C. (1995) Buyer-supplier co-operation for effective innovation. *M 2000 Executive Report*, No. 17, September, Lausanne, IMD.

Biemans, W. G. (1989) *Developing Innovations Within Networks*, Doctoral Thesis, Faculty of Industrial Engineering and Management Science, Eindhoven University of Technology.

Birou, L.M. (1994) *The Role of the Buyer-Supplier Linkage in an Integrated Product Development Environment*, doctoral thesis, Michigan State University.

Birou, L.M. and Fawcett, S.E. (1994) Supplier involvement in integrated product development: a comparison of US and European practices. *International Journal of Physical Distribution and Logistics Management*, Vol. 24, No. 5, pp. 4-14.

Blankenburg, D. and Johanson, J. (1990) Managing network connections in international business. *Scandinavian International Business Review*, Vol. 1, pp. 5-19.

Blau, P. (1964) *Exchange and power in social life*. New York: John Wiley.

Blois, K.J. (1972) Vertical quasi integration. *Journal of Industrial Economics (UK)*, Vol. 20, No. 3, July, pp. 253-271.

Blois, K.J. (1998) When is a relationship a 'relationship'? In Gemünden, H-G., Ritter, T. and Walter, A. (eds.), *Relationships and Networks in International Markets*, Elsevier Science Ltd.

Bonaccorsi, A. and Lipparini, A. (1994) Strategic partnerships in new product development: an Italian case study. *Journal of Product Innovation Management*, Vol. 11, pp. 134-145.

Booz, Allen, and Hamilton (1971) *Management of New Products*, New York: Booz, Allen and Hamilton Inc.

Booz, Allen, and Hamilton (1982) *New Product Management for the 1980s*, New York: Booz, Allen and Hamilton Inc.

Bower, D.J. (1993) New product development in the pharmaceutical industry: pooling network resources. *Journal of Product Innovation Management*, Vol. 10, pp. 367-75.

Bower, D.J. and Whittaker, E. (1993) Global R&D networks: the case of the pharmaceutical industry. *Journal of Industry Studies*, Vol. 1, No. 1, pp. 50-64.

Bower, D.J. and Keogh, W. (1997) Conflict and co-operation in technology-based alliances. *International Journal of Innovation Management*, Vol. 1, No. 4, pp. 387-409.

Bowersox, D.J., Closs, D.J. and Helferich, O.K. (1986) *Logistical Management* (3rd edition). Macmillan Publishing.

Bradach, J.L. and Eccles, R.G. (1989) Markets versus hierarchies: from ideal types to plural forms. *Annual Review of Sociology*, Vol. 15, pp. 97-118.

Brass, D.J. and Burckhardt, M.E. (1992) Centrality and Power in Organisations. In: N. Nohria, N. and Eccles, R.G. (eds.), *Networks and Organisations*, Harvard Business School Press, Boston, MA.

Brennan, R. and Turnbull, P.W. (1997) The process of adaptation in inter-firm relationships. In *Relationships and Networks in International Markets*, Gemünden, H.-G., Ritter, T. and Walter, A. (eds.), pp. 65-80, Elsevier Science Ltd.

Brennan, R and Turnbull, P.W. (1999) Adaptive Behaviour in Buyer-Supplier Relationships, *Industrial Marketing Management*, Vol. 28, Issue 5, pp. 481-495

Brown, S.L. and Eisenhardt, K.M. (1995) Product development: past research, present findings, and future directions. *Academy of Management Review*, Vol. 20, No. 2, pp. 343-378.

Bruce, M, Leverick, F. and Littler, D. (1995) A management framework for collaborative product development. In Bruce, M. and Biemans, W.G. (ed.) *Product Development: Meeting the Challenge of the Design-Marketing Interface*, John Wiley & Sons.

Burt (1983) *Corporate profits and cooptation: networks of markets constraints and directorate ties in the American economy.* New York: Academic press.

Caldwell, N. (2003) The treatment of power in supply chains: power, method and ontology, *Proceedings of the 12th International IPSERA Conference*, pp. 501-512, Budapest.

Calvi, R. and Le Dain, M-A. (2003) Collaborative development between client and supplier: how to choose the suitable coordination process? *Proceedings of the 12th International IPSERA Conference*, pp. 513-524, Budapest.

Chesbrough, H.W. and Teece, D.J. (1996) When is virtual virtuous? Organizing for innovation. *Harvard Business Review*, January-February, pp. 65-73.

Clark, K., Hayes, R. and Lorenz, C. (1985) *The Uneasy Alliance: Managing the Productivity-Technology Dilemma.* Cambridge: Harvard Business School Press.

Clark, K.B., Chew, W.B. and Fujimoto, T. (1987) Product development in the world auto industry. *Brookings Papers on Economic Activity,* No. 3, pp. 729-771.

Clark, K.B. (1989) Project scope and project performance: the effects of parts strategy and supplier involvement on product development. *Management Science*, Vol. 35, No. 10, October, pp. 1247-1263.

Clark, K.B. and Fujimoto, T. (1991) *Product Development Performance: Strategy, Organization, and Management in the World Auto Industry.* Cambridge: Harvard Business School Press.

Cohen, W.M. and Levinthal, D.A. (1990) Absorptive capacity: a new perspective on learning and innovation. *Administrative Science Quarterly*, Vol. 35, pp. 128-152.

Cook, K.S. and Emerson, R.M. (1978) Power, equity, commitment in exchange networks. *American Sociological Review*, Vol. 43, No. 5, pp. 721-738.

Cook, K.S. and Emerson, R.M. (1984) Exchange networks and the analysis of complex organisations. *Research in the Sociology of Organisations*, Vol. 3, Greenwich, Conn., JAI Press, pp. 1-30.

Cooper, R.G. (1979) The dimensions of industrial new product success and failure. *Journal of Marketing*, Vol. 43, pp. 93-103.

Cooper, R.G. (1982) New product success in industrial firms. *Industrial Marketing Management*, Vol. 11, pp. 215-223.

Cooper, R.G. (1983) A process model for industrial new product development. *IEEE Transactions on Engineering Management*, Vol. EM-30, No. 1, February, pp. 2-11.

Cooper, R.G. (1984) The strategy-performance link in product innovation. *R&D Management*, Vol. 14, No. 4, pp. 247-267.

Cooper, R.G. and Kleinschmidt (1987) What separates winners from losers? *Journal of Product Innovation Management*, Vol. 4, pp. 169-184.

Cooper, R.G. (1993) *Winning at New Products*, Reading, MA: Addison-Wesley.

Cousins, P.D. (2002) A conceptual model for managing long-term inter-organisational relationships. *European Journal of Purchasing and Supply Management*, Vol. 8, No. 2, pp. 71-82.

Cova, B., Mazet, F., and Salle, R., (1998) From districts to millieux: in search of network boundaries. In *Network Dynamics in International Marketing*, Naudé, P. and Turnbull, P. W., pp. 195- 210, Elsevier Science Ltd, UK.

Cox, A. (1996) Relational competence and strategic procurement management: towards an entrepreneurial and contractual theory of the firm. *European Journal of Purchasing and Supply Management*, Vol. 2, No 1, pp. 57-70.

Cox, A., Sanderson, J., and Watson, G. (2000) Power regimes: a new perspective on managing in supply chain networks. *Proceedings of the 10th IPSERA Conference*, Jönkoping, Sweden, pp. 215-228.

Cravens, D.W., Piercy, N. F. and Shipp, S. H. (1996) New organisational forms for competing in highly dynamic environments: the network paradigm. *British Journal of Management*, Vol. 7, pp. 203-218.

Crawford, (1980) Defining the charter for product innovation. *Sloan Management Review*, Fall, pp. 3-12.

Dahl, R.A. (1961) *Who Governs? Democracy and Power in an American City*, New Haven, Yale University Press.

David, P.A. (1985) *Path Dependence: Putting the Past into the Future of Economics*, Technical Report No. 533, The Economics Series, Institute for Mathematical Studies in the Social Sciences, University of Stanford, Stanford, CA.

Dean, J.W. and Susman, G.I. (1989) Organizing for manufacturable design. *Harvard Business Review*, Jan-Feb.

DeBresson, C. and Amesse, F. (1991) Networks of innovators: a review and introduction to the issue. *Research Policy*, Vol. 20, No 5, pp. 363-379

Department of Trade and Industry (1998) *The Competitiveness White Paper: Our Competitive Future: Building the Knowledge Driven Economy.*

DeTienne, D.R. and Koberg, C.S. (2002) The impact of environmental and organizational factors on discontinuous innovation within high-technology industries. *IEEE Transactions on Engineering Management*, Vol. 49, No. 4, pp. 352-387.

Diamanescu, D., Hines, P. and Rich, N. (1997) *The Lean Enterprise: Designing and Managing Strategic Processes for Customer-Winning Performance*, New York, AMACOM.

Dicken, P. (2003) *Global shift: reshaping the global economic map in the 21st century.* 4th ed. Sage, London.

Doran, D. (2003) Supply chain implications of modularization. *International Journal of Operations & Production Management*, Vol. 23, No. 3, pp. 316-326.

Dosi, G. (1982) Technological paradigms and technological trajectories: a suggested interpretation of the determinants and direction of technical change. *Research Policy*, Vol. 11, No. 3, pp. 147-162, Elsevier: Amsterdam.

Dougherty, D. (1995) Managing your core incompetencies for corporate venturing. *Entrepreneurship: Theory and Practice*, Vol. 19, 3, pp. 113-135.

Doyle, J.L. (1985) Commentary. Managing new product development: how Japanese companies learn and unlearn. In Clark, K., Hayes, R. and Lorenz, C. (1985) *The Uneasy Alliance: Managing the Productivity-Technology Dilemma.* Cambridge: Harvard Business School Press.

Doz, Y.L. (1996) The evolution of cooperation in strategic alliances: Initial conditions or learning processes. *Strategic Management Journal*, Summer Special Issue, Vol. 17, pp. 55-84.

Dowlatshahi, S. (1992) Purchasing's role in a concurrent engineering environment. *International Journal of Purchasing and Materials Management*, Winter, pp. 21-25.

Dröge, C., Jayaram, J. and Vickery, S.K. (2000) The ability to minimize the timing of new product development and introduction: an examination of antecedent factors in the North American automobile supplier industry. *Journal of Product Innovation Management*, Vol. 17, pp. 24-40.

Drucker, P. (1946) *The Concept of the Corporation*, John Day: New York.

DTI (1994) *Innovation-Your Move*, Department of Trade and Industry, London.

Dubois, A. (1998) *Organising Industrial Activities Across Firm Boundaries*, London; Routledge.

Dubois, A. and Gadde, L.-E. (1999) Case studies in business market research: an abductive approach. *Proceedings of the 15th IMP Conference, Interactions, Relationships and Networks: Towards the New Millenium*, The Michael Smurfit Graduate School of Business, Dublin, 2-4 September.

Dubois, A. and Gadde, L.-E. (2002) Systematic combining: an abductive approach to case research, *Journal of Business Research*, Vol. 55, Issue 7, pp. 553-560.

Dwyer, F.R., Shurr, P.H. and Oh, S. (1987) Developing buyer-seller relationships. *Journal of Marketing*, Vol. 51, pp. 11-27.

Dyer, W.G. and Wilkins, A. L. (1991) Better stories, not better constructs, to generate better theory: a rejoinder to Eisenhardt. *Academy of Management Review*, Vol. 16, No. 3, pp. 613-619.

Dyer, J. H. and Ouchi, W. G. (1993) Japanese-style partnerships: giving companies a competitive edge. *Sloan Management Review*, Fall, pp. 51-63.

Dyer, J.H. (1996) Specialised supplier networks as a source of competitive advantage: evidence from the auto industry. *Strategic Management Journal*, Vol. 17, pp. 271-291.

Dyer, J. and Nobeoka, K. (2000) Creating and Managing a High Performance, Knowledge Sharing Network: The Toyota Case, *Strategic Management Journal*, Vol. 21, pp. 345-367.

Easterby-Smith, R. M. Thorpe, Lowe, A. (1991) *Management Research. An Introduction*, London, Sage Publications Ltd.

Easton, G. (1992) Industrial networks: a review, in Axelsson, B. and Easton, G. *Industrial Networks: A New View of Reality*, Routledge, London

Easton, G. and Håkansson, H. (1996) Markets as networks: editorial introduction. *International Journal of Research in Marketing*, Vol. 13, No 5 (December), pp 407-13.

Easton, G. (1998) Case research as a methodology for industrial networks: a realist apologia. In *Network Dynamics in International Marketing*, Naudé, P. and Turnbull P. W. (eds), Pergamon Press, London, pp. 73-87.

Easton G. (2002) Marketing: a critical realist approach. *Journal of Business Research*, Vol. 55 (2), pp. 103-109, ISSN: 01482963.

Eisenhardt, K.M. (1989) Building theories from case study research. *Academy of Management Review*, Vol. 14, No. 4, pp. 532-550.

Eisenhardt, K.M. and Tabrizi, B. N. (1995) Accelerating adaptive processes: product innovation in the global computer industry. *Administrative Science Quarterly*, Vol. 40, March, pp. 84-110.

Ellram, L. and Billington, C. (2001) Purchasing leverage considerations in the outsourcing decision. *European Journal of Purchasing and Supply Management*, Vol. 7, pp. 15-27.

Emerson, R.M. (1962) Power-dependence relations. *American Sociological Review*, Vol. 27, No. 1, pp. 31-41.

Emerson, R.M. (1981) Social exchange theory. In Rosenberg, M. and Turner, R. (eds.), *Social Psychology: Sociological Perspectives*, Basic Books, New York

England, W. (1970) *Modern Procurement Management: Principles and Cases*, 5th ed. Edn, Irwin: Homewood, IL.

Fairhead, J. and Griffin, R. (2000) The power potential of the less-powerful within networks. *Proceedings of the 15th Annual IMP Conference, Interactions, Relationships and Networks: Towards the New Millenium*, The Michael Smurfit Graduate School of Business, Dublin, 2 – 4 September.

Ford, I.D. (1980) The development of buyer-seller relationships in industrial markets. *European Journal of Marketing*, Vol. 14, No. 3, pp. 72-84.

Ford, D. Håkansson, H. and Johanson, J. (1986) How do Companies Interact? *Industrial Marketing and Purchasing*, Vol. 1, No. 1, pp. 26-41.

Ford, I.D. (ed.) (1990*) Understanding Business Markets: Interactions, Relationships and Networks*, Academic Press, San Diego, CA.

Ford, D. and Saren, M. (1996) First Steps in Technology Strategy, in *Technology Strategy for Business*, Croom Helm, New York, pp. 41-52.

Ford, I.D. and Saren, M. (2001) *Managing and Marketing Technology*, Thomson Learning, London.

Ford, D. and Håkansson, H. (2002) How should companies interact in business networks? *Journal of Business Research*, Vol. 55, pp. 133-139.

Ford, D., Gadde, L-E., Håkansson, H. and Snehota, I. (2003) *Managing Business Relationships*, Wiley, 2nd ed., Chichester, England.

Foxall, G.R. and Tierney, J.D. (1984) From CAP1 to CAP2: user initiated product innovation from the user's point of view. *Management Decision*, Vol. 22, No. 5, pp. 3-15.

Foxall (1986) A conceptual extension of the customer-active paradigm. *Technovation*, Vol. 4, pp. 17-27.

Foxall, G.R. and Johnston, B. (1987) Strategies of user-initiated product innovation. *Technovation*, Vol. 6, pp. 87-102.

Frazier, G. and Antia, K. (1995) Exchange relationships and interfirm power in channels of distribution. *Journal of Academy of Marketing Science*, Vol. 23, No. 4, pp. 321-326.

Freeman, C. (1979) The determinants of innovation; market demand, technology, and the response to social problems. *Futures*, June, p. 208.

Freeman, C. (1982) *The Economics of Industrial Innovation*. London: Pinter.

Freeman, C. and Perez, C. (1988) Structural crisis of adjustment, business cycles and investment behaviour. In Dosi, G. (ed.) Technical Change and economic Theory, Frances Pinter: London.

Freeman, C. (1991) Networks of innovators: a synthesis of research issues. *Research Policy,* Vol. 20, No 5, pp. 499-514.

Freeman, C. (1994) Critical survey: the economics of technical change. *Cambridge Journal of Economics*, Vol. 18, pp. 463-514.

Gadamer, H-G. (1960) *Truth and Method,* 2nd revised ed., trans. J. Weinsheimer and D.G. Marshall (1989), New York: Continuum.

Gadde, L-E. and Håkansson, H. (2001) *Supply Network Strategies*, John Wiley & Sons Ltd.

Gadde, L.E. and Jellbo, O. (2002) System sourcing- opportunities and problems. *European Journal of Purchasing and Supply Management*, Vol. 8, pp. 43-51.

Galaskiewicz, J. (1996) The 'new network analysis' and its application to organizational theory and behaviour. In Iacobucci, D. (1996) *Networks in Marketing*, Sage: USA.

Gehani, R.R. (1992) Concurrent product development for fast-track corporations. *Long Range Planning*, Vol. 25, No. 6, pp. 40-47.

Gemünden, H-G. (1997) The development of IMP – an analysis of the conference proceedings 1984-96. In Gemünden, H-G., Ritter, T. and Walter, A. (eds.), *Relationships and Networks in International Markets*, Elsevier Science Ltd.

Georghiu, L., Metcalfe, J.S., Gibbons, M., Ray, T., and Evans, J. (1986) *Post-Innovation Performance: Technological Development and Competition*, MacMillan: London.

Ghoshal, S. and Bartlett, C.A. (1988) Innovation processes in multinational corporations. In *Readings in the Management of Innovation.* Ed: Tushman, M.L. and Moore, W.L., US: Ballinger Publishing Company.

Glaser, B. and Strauss, A. (1967) *The Discovery of Grounded Theory. Strategies for Qualitative Research.* Chicago: Aldine.

Gobeli, D.H. and Brown, D.J. (1987) Analyzing product innovations. *Research Management*, July-August.

Godwin, A, Gleeson J and William. D (1989) An assessment of the IDEF notations as descriptive tools. *Information Systems*, Vol. 14, No. 1, January, pp. 13-28.

Grandori, A. and Soda, G. (1995) Inter-firm networks: antecedents, mechanisms and forms. *Organization Studies*, Vol. 16, No. 2, pp. 183-214.

Granovetter, M.S. (1973) The strength of weak ties. *American Journal of Sociology*, Vol. 78, pp. 1360-1380.

Granovetter, M.S. (1985) Economics action and social structure: the problem of embeddedness. *American Journal of Sociology*, Vol. 91, No. 3, pp. 481-510.

Granstrand, O., Patel, P, and Pavitt, K. (1997), Multi-technology corporations: why they have 'distributed' rather than 'distinctive core' competencies. *California Management Review*, Vol. 39, No. 4, Summer, pp. 1-19.

Gulati, R. (1998) Alliances and Networks. *Strategic Management Journal*, Vol. 19, pp. 293-317.

Häcki, R. and Lighton, J. (2001) The future of the networked company. *The McKinsey Quarterly*, No. 3, pp. 26-39.

Håkansson, H., Johanson, J., Wootz, B. (1977) Influence tactics in buyer-seller processes, *Industrial Marketing Management*, Vol. 5, pp. 319-32.

Håkansson, H. (ed) (1982) *International Marketing and Purchasing of Industrial Goods: An Interaction Approach*, Chichester, Wiley.

Håkansson H, (ed.) (1987) *Industrial Technological Development: A Network Approach*, Croom Helm, London

Håkansson, H. and Johanson, J. (1987) Formal and informal co-operation strategies in international industrial networks. In Contractor, F.J and Lorange, P. (eds.), *Co-operative Strategies in International Business*, Lexington Books.

Håkansson, H., Johanson, J. (1988) A network model. In Axelsson, B., Easton, G., (eds.) *Industrial Networks. A New View of Reality*. London: Routledge.

Håkansson, H. (1989) *Corporate Technological Behaviour, Co-operation and Networks,* London Routledge.

Håkansson, H. and Snehota, I. (1990) No business is an island: the network concept of business strategy. *Scandinavian Journal of Management*, Vol. 4, No. 3, pp. 187-200.

Håkansson, H. and Henders, B. (1992) International co-operative relationships in technological development. In *Managing Networks in International Business*, Forsgren, M. and Johanson, J. (eds.) Gordon and Breach Science Publishers.

Håkansson, H. and Johanson, J. (1992) A model of industrial networks. In *Industrial Network: a New View of Reality*, Routledge, London, pp. 28-34.

Håkansson, H. and Eriksson, A-K. (1993) Getting innovations out of supplier networks. *Journal of Business-to-Business Marketing*, Vol. 1, No. 3, pp. 3-34.

Håkansson, H. and Snehota, I (1995) *Developing Relationships in Business Networks*, International Thomson Business Press, London.

Håkansson, H. and Lundgren, A. (1997) Paths in time and space – path dependence in industrial networks. In L. Magnusson and J. Ottoson (eds.), *Evolutionary Economics and Path Dependence*, Cheltenham, Edward Elgar, pp. 119-137.

Håkansson, H. and Snehota, I. (1998) The burden of relationships or who's next? In P. Naudé and P. W. Turnbull, *Network Dynamics in International Marketing*, Oxford, Elsevier Science.

Håkansson, H. and Snehota, I. (2000) The IMP perspective, assets and liabilities of relationships. In J. Sheth (ed.), *Handbook of Relationship Marketing*, Sage, Thousand Oaks, CA.

Håkansson, H. and Johansson, J. (2001) Business network learning- basic considerations. In H. Håkanssoon and J. Johansson (eds.), *Business Network Learning* (pp. 1-16), Oxford: Elsevier Science Ltd.

Håkansson, H., and Waluszewski, A. (2002) Path Dependence: Restricting or Facilitating Technological Development. *Journal of Business Research*, Vol. 55, Issue 7, pp. 561-570.

Hagedoorn, J. and Schakenraad, J. (1990) Inter-firm partnerships and co-operation strategies in core technologies, in Freeman, C. and Soete, L. (eds.): *New Explorations in the Economics of Technological Change*, Pinter Publishers, London & New York, pp. 3-87.

Hagedoorn, J. (1993) Understanding the rationale of strategic technology partnering: Interorganizational modes of cooperation and sectoral differences. *Strategic Management Journal*, Vol. 14, pp. 371-385.

Hagedoorn, J. (1995) Strategic technology partnering during the 1980s: trends, networks and corporate patterns in non-core technologies. *Research Policy*, Vol. 24, pp. 207-241.

Hamel, G., Doz, Y.L. and Prahalad, C.K. (1989) Collaborate with your Competitors and Win. *Harvard Business Review*, Vol. 67, pp. 133-139.

Hamel, G. (2000) *Leading the Revolution*, Harvard Business School Press, Boston, Massachusetts.

Han, S.L., Wilson, D.T. and Dant, S.P. (1993) Buyer-supplier relationships today. *Industrial Marketing Management*, Vol. 22, pp. 331-338.

Handfield, R.B., Ragatz, G.L., Petersen, K.J., Monczka, R.M. (1999) Involving suppliers in new product development. *California Management Review*, Vol. 42, No. 1, Fall, pp. 59-82.

Hansen, P. K., Gubi, E. and Hansen, B. G. (2002) Modularity and distributed product development, the *9th International Product Development Conference*, Sophia Antipolis, France, May 27-28, pp. 393-402.

Harland, C.M. (1996) Supply Chain Management: Relationships, Chains and Networks, *British Journal of Management*, Vol. 7, Special Issue, S63-S80.

Harland C.M. and Wensley J.R. (1996) Supply Chain Management as a Response to the Strategy Leaf Kickers. Working Paper, *Proceedings of British Academy of Management Annual Conference*, Aston Business School.

Harland, C.M. and Knight, L.A. (2001), Supply network strategy: role and competence requirements. *International Journal of Production and Operations Management*, Vol. 21, No. 4, pp. 476-489.

Harland, C.M., Zheng, J., Lamming, R.C., Johnsen, T.E. (2001) A taxonomy of supply networks. *The Journal of Supply Chain Management*, Vol. 37, No. 4, Fall 2001 Issue, pp. 21-27.

Harland, C.M., Zheng, J., Johnsen. T. and Lamming. R.C. (2003) A conceptual model for researching the creation and operation of supply networks. *British Journal of Management* (forthcoming).

Harrison, D. (2004) Network effects following multiple relationship dissolution. Forthcoming in *Journal of Management Studies*, Vol. 41, No. 1, pp. 107-125.

Hart, S. (ed.) (1996) *New Product Development: A Reader*, London: Dryden Press.

Hartley, J. L. (1994) *Understanding supplier involvement in their customer's product development*, doctoral thesis, Department of Quantitative Analysis and operations Management, University of Cincinnati.

Hartley, J. L., Zirger, B. J. and Kamath, R. R. (1997) Managing the buyer-supplier interface for on-time performance in product development, *Journal of Operations Management*, Vol. 15, pp. 57-70.

Heide, J. B. (1994) Interorganizational governance in marketing channels. *Journal of Marketing*, Vol. 58, pp. 71-85.

Helper, S. (1990) An Exit-Voice Analysis of Supplier Relations, Working paper number 90-23, Boston University, presented at the 2nd Annual International Conference on Socio-Economics, Washington, D.C., March 1990.

Herstatt, C. and Von Hippel, E. (1992) From experience: developing new product concepts via the lead user method: a case study in a 'low-tech' field. *Journal of Product Innovation Management*, Vol. 9, pp. 213-221.

Hertz, S. (1996) Drifting closer and drifting away in networks: gradual changes in interdependencies of networks. In Iacobucci, D. (1996) *Networks in Marketing*, Sage, pp. 179-204.

Hess, D.J. (1997) *Science Studies: An Advanced Introduction*. New York University Press: New York. Cited in Kwan and Tsang (2001).

Hines, P. (1996) Network Sourcing. In Lamming, R.C. and Cox, A. (eds.) *A Strategic Procurement Management in the 1990s: Concepts and Cases*, Boston, Earlsgate Press, UK.

Hines, P. Lamming, R. C., Jones, D., Cousins, P, Rich, N. (2000) *Value Stream Management*, Pearson Education.

Hirschman, A. (1970) *Exit, Voice, and Loyalty: Responses to Decline in Firms, Organisations and States*, Harvard University Press, Cambridge, MA.

Holt, K. (1983) *Product Innovation Management*, Butterworths, London.

Humer, L. (1998) *Trust*, Umeå: Borea Bokforlag.

Iacobucci, D. (1996) *Networks in Marketing*, Sage: USA.

Iansiti, M. and Clark, K. (1994) Integration and dynamic capability: Evidence from product development in automobiles and mainframe computers. *Industrial and Corporate Change*, Vol. 3, No. 3, pp. 557-605

ICAM (1981) *Architecture Part II Volume IV Function Modelling Manual (IDEF0) AFWAL-TR-81-4023*, Wright-Patterson Air Force Base. OH. USA

Imai, K, Nonaka, I., and Takeuchi, H. (1985) Managing the new product development process: how Japanese companies learn and unlearn. In K. Clark, R. Hayes and C. Lorentz (eds) *The Uneasy Alliance: Managing the Productivity-Technology Dilemma*, Harvard Business School Press: Cambridge, MA, pp. 337-381.

Imai, K and Baba, Y. (1989) System innovation and cross-border networks: transcending markets and hierarchies to create a new techno-economic system, Paper presented at the *International Seminar on the Contributions of Science and Technology to Economic Growth* at the OECD, Paris, June.

Itami, H. and Roehl, T. (1987) *Mobilizing Invisible Assets*. Cambridge, MA: Harvard University Press.

Jarillo, J.C. (1988) On strategic networks. *Strategic Management Journal*, Vol. 9, pp. 31-41.

Jarillo, J.C. and Stevenson, H.H. (1991) Co-operative Strategies: The Payoffs and the Pitfalls, *Long Range Planning*, Vol. 24, No. 1, pp. 64-70.

Jarillo, J.C. (1993) *Strategic Networks: Creating the Borderless Organisation*, Butterworth Heinemann, Oxford.

Johanson, J. and Vahlne, J-E. (1977) The internationalization process of the firm-a model of knowledge development and increasing foreign market commitments. *Journal of International Business Studies*, Vol. 8, pp. 23-32.

Johanson J. and Mattsson L.G. (1987) Inter-organisational relations in industrial systems: a network approach compared with a transaction cost approach. *International Studies of Management and Organisation*, Vol. 18, No 1, pp. 34-48.

Johanson, J. (1989) *Business Relationships and Industrial Networks*, Reprint Series 1989/7, Department of Business Studies, University of Uppsala.

Johanson, J. and Mattsson, L-G. (1992) Network positions and strategic action – an analytical framework. In *Industrial Network: a New View of Reality*, Routledge, London, pp. 205-214.

Johne, F.A. (1985) *Industrial Product Innovation: Organisation and Management*, Croom Helm, London.

Johnsen, R.E. and Ford, I.D. (2002) Developing the concept of asymmetrical and symmetrical relationships: linking relationship characteristics and firms' capabilities, *Proceedings of the 18th Annual IMP Conference*, September 5th-7th, ESC, Dijon, France.

Johnsen, T. E., Wynstra, F, Zheng, J, Harland, C, Lamming, R C: (2000) Networking activities in supply networks. *Journal of Strategic Marketing*. Vol. 8, No. 2.

Johnsen, T.E. (2000) How can companies manage supply networks? *DILF Orientering*, Dansk Indkøbs- og Logistik Forum (Danish Purchasing and Logistics Forum), December – January, pp. 10 – 16.

Johnsen, T.E. and Ford, I.D. (2000) Managing collaborative innovation in complex networks: findings from exploratory interviews. *16th Annual IMP Conference*, Bath, 7 – 9 September.

Kale, P., Singh, H., and Perlmutter, H. (2000) Learning and protection of proprietary assets in strategic alliances: building relational capital. *Strategic Management Journal*, Vol. 21, pp. 217-237.

Kamath, R.R. and Liker, J.K. (1994) A second look at Japanese product development. *Harvard Business Review*, October-November, pp. 154-170.

Karlsson, C. and Åhlström, P. (1996) The difficult path to lean product development. *Journal of Product Innovation Management*, Vol. 13, pp. 283-295.

Karlsson, C., Nellore, R. and Söderquist, K. (1998) Black box engineering: redefining the role of product specifications. *Journal of Product Innovation Management*, Vol. 15, pp. 534-549.

Kassicieh, S., Walsh, S.T., Romig, A.D., Cummings, J.C., McWhorter, P. and Williams, D. (2002) Factors differentiating the commercialization of disruptive and sustaining technologies. *IEEE Transactions on Engineering Management*, Special Issue on Disruptive Technologies and Discontinuous Innovations, November.

Kirkeby, O. F. (1990) *Abduktion* (Abduction). In Andersen, H. (ed.) Videnskabsteori og Metodelære: Introduktion, pp. 57-78, 3rd ed., Samfundsliteratur, Denmark.

Knight, K. (1967) A descriptive model of the intra-firm development process. *Journal of Business*, Vol. 40, October, pp. 478-96.

Knight, L. (2002) Network learning: exploring learning by inter-organizational networks. *Human Relations*, April, Vol. 55, No. 4.

Kotabe, M. Swan, K.S. (1996) The role of strategic alliances in high-technology new product development, *Journal of Product Innovation Management*, Vol. 13, No. 3, pp. 266-266.

Kothandaraman, P. and Wilson, D. T. (1999) Aligning the organisation for successful partnerships. In *Interactions, Relationships and Networks: Towards the New Millennium*, McLoughlin, D. and Horan, C. (eds), 15th Annual IMP Conference, The Michael Smurfit Graduate School of Business, Dublin, Ireland.

Kotler, P. (1994) *Principles of Marketing*, sixth ed., Prentice Hall.

Kuhn, T. (1962) *The Structure of Scientific Revolutions*, 2d ed. Chicago: University of Chicago Press in Stacey, R. (1993). *Strategic Management and Organisational Dynamics*. Pitman Publishing.

Kumar, N. (1996) The power of trust in manufacturer-retailer relationships. *Harvard Business Review*, Nov-Dec, pp. 92-106.

Kwan, K-M. and Tsang, E. W. K. (2001) Realism and constructivism in strategy research: a critical realist response to Mir and Watson. *Strategic Management Journal*, Vol. 22, pp. 1163-1168.

Laage-Helman, J. (1987) Process innovation through technical cooperation. In *Industrial Technological Development*, Håkansson, H. (ed.), London, Routledge, pp. 26-83.

Lambe, C. J. and Spekman, R.E. (1997) Alliances, External Technology Acquisition, and Discontinuous Technological Change. *Journal of Product Innovation Management*, Vol. 14, pp. 102-116.

Lamming, R. C. (1993) *Beyond Partnership: Strategies for Innovation and Lean Supply*. Prentice Hall.

Lamming, R. C. (1996) Squaring lean supply with supply chain management. *International Journal of Operations and Production Management*, Vol. 16, No. 2, pp. 183-196.

Lamming, R. C., Johnsen, T. Harland, C. M. and Zheng, J. (2000a) An initial classification of supply networks. *International Journal of Operations and Production Management*, Vol. 20, No. 6, pp. 675 - 691.

Lamming, R. C., Johnsen, T, Harland, C.M. and Zheng, J (2000b) Managing in Supply Networks: Cascade and Intervention. *9th International Annual IPSERA Conference*, University of Western Ontario, Canada, May 24-27.

Lamming, R.C., Caldwell, N., Harrison, D. and Phillips, W. (2001) Transparency in supply relationships: concept and practice. *Proceedings of the 10th International Annual IPSERA Conference,* Jönköping International Business School, April.

Lee, L. Jr. and Dobler, D. W. (1971) *Purchasing and Materials Management: Text and Cases*, 2nd ed., McGraw Hill: New York.

Leonard-Barton, D. (1992) Core capabilities and core rigidities: a paradox in managing new product development. *Strategic Management Journal*, Vol. 13, pp. 111-125.

Leonard-Barton, D. (1995) *Wellsprings of Knowledge*. Boston: Harvard Business School Press.

Lewis, P. A. (2001) Metaphor and critical realism. *Review of Social Economy*, Vol. LIV, No. 4, Winter, pp. 487-506.

Lincoln, Y. and Guba, E. (1985) *Naturalistic Inquiry*. London: Sage.

Lindquist, M. (1996) Innovation networks among small firms: the relative importance of 'local environment' over the innovation process. *41st ICSB Conference Proceedings*, Stockholm 17-19 June.

Linton, J.D. (2002) Forecasting the Market Diffusion of Disruptive and Discontinuous Innovation, *IEEE Transactions on Engineering Management*, November 2002 Vol. 49, No. 4, pp. 365-374.

Littler, D., Leverick, F., and Bruce, M (1995) Factors affecting the process of collaborative product development: a study of UK manufacturers of information and communications technology products. *Journal of Product Innovation Management*, Vol. 12, No. 1 (January), pp. 1-18.

Lonsdale, C. (2001) Locked-In to Supplier Dominance: On the dangers of asset specificity for the outsourcing decision. *Journal of Supply Chain Management*, Vol. 37, No. 2, pp. 22-27.

Lorenzoni, G. and Baden-Fuller, C. (1995) Creating a strategic centre to manage a web of partners. *California Management Review*, Vol. 37, No. 3, Spring,

Lukes, S. (1974) *Power, A Radical View*, London, Macmillan Press.

Lundgren, A. (1993) Technological innovation and the emergence and evolution of industrial networks: the case of digital image technology in Sweden. *Advances in International Marketing*, Vol. 5, pp. 145-170.

Lundgren, A. (1995) *Technological Innovation and Network Evolution*, Routledge, London

Lundvall, B. Å. (1986) Product innovation and user-producer interaction. *Industrial Development Research Series*, No. 31. Aalborg University Press.

Madhok, A. (1995) Opportunism and trust in joint venture relationships: an exploratory study and a model, *Scandinavian Journal of Management*, Vol. 11, No. 1, pp. 57-74.

Mansfield, E. Schwartz, M. and Wagner, S. (1981) Imitation costs and patents: an empirical study. *Economic Journal*, Vol. 91 (December), pp. 907-918.

Mansfield, E. (1985) How rapidly does new industrial technology leak out? *Journal of Industrial Economics*, Vol. 34, No. 2 (December), pp. 217-223.

Martin, M.J.C. (1984) *Managing Technological Innovation and Entrepreneurship*, Reston Publishing Company, Inc., Reston, Virginia.

Mattsson, L-G. (1984) An application of a network approach to marketing: defending and changing market positions. In N. Dholakia and J. Arndt (eds.) *Changing the Course of Marketing. Alternative Paradigms for Widening Marketing Theory*, Greenwich, Conn., JAI Press.

McCarthy, E.J. (1960) *Basic Marketing*, Homewood, III., Irwin, in Kotler, P. (1994). *Principles of Marketing*, sixth ed., Prentice Hall.

McGloin, E. and Grant, C. (1998) Supporting partnership sourcing in northern ireland through advanced technology. *Technovation*, Vol. 18, Issue 2, pp. 91-99.

Mensch, G. (1975) *Das Technologische Patt*, Frankfurt, Umschau.

Miaoulis, G. and LaPlaca, P.J. (1982) A systematic approach for developing high-technology products. *Industrial Marketing Management*, Vol. 11, pp. 253-262.

Miles, M. and Huberman, A. (1984) *Qualitative Data Analysis: a Sourcebook of New Methods*, Newbury Parl and London: Sage.

Mintzberg, H. (1992) Five Ps for strategy. In H. Mintzberg and J.B. Quinn, (eds.), *The Strategy Process: Concepts and Contexts*, pp. 12-19, Englewood Cliffs, NJ, Prentice-Hall International Editions.

Mintzberg, H. and Quinn, J. B. (1992) *The Strategy Process: Concepts and Contexts*, Prentice-Hall International.

Mir, R. And Watson, A. (2001) Critical realism and constructivism in strategy research: towards a synthesis. *Strategic Management Journal*, Vol. 22, pp. 1169-1173.

Mitchell J.C. (1969) The Concept and Use of Social Networks. In J.C. Mitchell (ed) *Social Networks in Urban Situations*, Manchester University Press, Mainsheets, pp. 1-50.

Mohr, J. and Spekman, R. (1994) Characteristics of partnership success: partnership attributes communication behaviour and conflict resolution techniques. *Strategic Management Journal*, Vol. 15, pp. 135-152.

Monczka, R.M., Handfield, R.B. and Scannell, T.V. (2000) *New Product Development: Strategies for Supplier Integration*, Milwaukee: ASQ Quality Press.

Moore, R. A. (1984) Control of new product development in UK companies. *European Journal of Marketing*, Vol. 18, No. 6/7, pp. 5-13.

Morgan, G. (1986) *Images of Organisation*, Beverly Hills, California, Sage.

Mowery, D. (1988) *International Collaborative Ventures in US Manufacturing.* Cambridge: Ballinger.

Muranka, T. and Rootes, N. (1996) *Doing a Dyson.*

Myers, S. and Marquis, D.G. (1969) *Successful Industrial Innovations* (NSF 69-17). Washington DC: National Science Foundation.

Möller, K. E. and Halinen, A. (1999) Business relationships and networks: managerial challenge of network era. *Industrial Marketing Management*, Vol. 28, pp. 413-427.

Möller, K. and Svahn, S. (2002) Role of knowledge in the value creation of business nets. *18th Annual IMP Conference*, September 5th-7th, ESC, Dijon, France.

Möller, K. Rajala, A. and Svahn, S. (2002) Strategic business nets – their types and management. *Journal of Business Research*, forthcoming.

Møller, M. M. (2002) *Sourcing af Teknologi, Kompetencer og Viden i et Interorganisatorisk Leverandørperspektiv* (Sourcing of Technology, Competencies and Knowledge in an Inter-Organisational Supplier Perspective), Ph.D. Thesis, Centre for Industrial Production, Aalborg University, Denmark.

Naudé, P. and Turnbull, P. W. (1998) *Network Dynamics in International Marketing*, Oxford, Elsevier Science.

Naudé, P. and Buttle, F. (2000) Assessing relationship quality. *Industrial Marketing Management*, Vol. 29, Issue 4, pp. 351-361.

Naudé, P., Möller, K. and Ritter, T. (2002) MaGNeT - Managing in Global Networks, *Proceedings of the 18th Annual IMP Conference*, September 5th-7th, ESC, Dijon, France.

Nelson, R. and Winter, S. (1977) In search of a useful theory of innovation. *Research Policy*, Vol. 6, No. 1, pp. 36-76.

Nelson, R. and Winter, S. (1982) *An Evolutionary Theory of Economic Change.* Cambridge: Harvard University Press.

Newell, S., Swan, J. & Preston, J. (1998) Trust and inter-organisational networking. Paper presented at *British Academy of Management*, BAM, Conference, September, Nottingham.

Nishiguchi, T. (1994) *Strategic Industrial Sourcing*, Oxford & New York, Oxford University Press.

Nohria, N. (1992) Is a Network Perspective a Useful way of Studying Organisations? In N. Nohria and R. G. Eccles (eds.), *Networks and Organisations: Structure, Form, and Action*, Harvard Business School Press, Boston, MA, pp. 1-22.

Nonaka, I. (1988) Creating organisational order out of chaos: self-renewal in Japanese firms. *California Management Review*, Spring, pp. 57-73.

Nonaka, I. (1990) Redundant, overlapping organizations: a Japanese approach to managing the innovation process. *California Management Review*, Vol. 32, No. 3, pp. 27-38.

Nonaka, I. and Takeuchi, H. (1995) *The Knowledge Creating Company,* Oxford University Press, New York.

Nyström, H. (1990) *Technological and Market Innovation: Strategies for Product and Company Development.* Chichester: John Wiley and Sons.

OECD (1994) *Summary of the Frascati Manual.* http://www1.oecd.org/dsti/sti/stat-ana/prod/eas_fras.htm.

Oliver, N. and Wilkinson, B. (1988) *The Japanisation of British Industry*, Blackwell: Oxford.

Oliver, N. and Blakeborough, M. (1998) Innovation networks: the view form the inside. In Michie, J. and Grieve-Smith, J. (eds.) *Globalization, Growth and Governance*, Oxford: Oxford University Press, pp. 146-160.

Oliver, N., McCormack, U. and Anderson, J. (1999) Innovation networks for new product development in two contrasting sectors. *European Operations Management Association Sixth International Annual Conference*, Venice 7-8 June.

O'Neal, C. (1993) Concurrent engineering with early supplier involvement: a cross-functional challenge. *International Journal of Purchasing and Materials Management*, Spring, pp. 3-9.

Oxford Advanced Learner's Dictionary, Oxford University Press (2003)

Parkinson, S. T. (1982) The role of the user in successful new product development. *R&D Management*, Vol. 12, No. 3, pp. 123-31.

Pascale, R. T. (1990) *Managing on the Edge: How Successful Companies use Conflict to stay ahead*, London, Viking Penguin.

Pavitt, K. (1984) Sectoral patterns of technical change: towards a taxonomy and a theory. *Research Policy*, Vol. 13, No. 6, pp. 343-374.

Penrose, E. T. (1959/1995) *The Theory of the Growth of the Firm.* Basil Blackwell, Oxford., 3rd edition (1995). Oxford University Press

Peteraf, M. (1993) The cornerstones of competitive advantage: a resource-based view, *Strategic Management Journal*, Vol. 14, pp. 179-191.

Pfeffer, J. and Salancik, G.R. (1978) *The External Control of Organisations*, New York: Harper and Row.

Piore, M. and Sabel, C. (1984) *The Second Industrial Divide: Possibilities for Prosperity*, New York, Basic Books.

Pisano, G., Shan, W. and Teece, D. (1988) Joint ventures and collaboration in the biotechnology industry. In D. Mowery (ed.) *International Collaborative Ventures in US Manufacturing*, Ballinger: Cambridge, MA.

Pisano, G. (1997) *The Development Factory-Unlocking the Potential of Process Innovation*, Harvard Business School Press, Boston, Massachusetts.

Porter, M.E. (1980) *Competitive Strategy*. The Free Press, New York.

Porter, M.E. (1985) *Competitive Advantage: Creating and Sustaining Superior Performance*, Free Press.

Porter, M.E. (1991) Towards a dynamic theory of strategy. *Strategic Management Journal*, Vol. 12, Special Issue, pp. 95-117.

Powell, W.W., Koput, K.W., Smith-Doerr, L (1996) Inter-organisational collaboration and the locus of innovation: networks of learning in biotechnology. *Administrative Science Quarterly*, Vol. 41, No. 1, pp. 116-145.

Prahalad, C.K. and Hamel, G. (1990) The core competencies of the corporation. *Harvard Business Review*, May-June, pp. 71-91.

Prahalad, C.K. and Hamel, G. (1992) Comment to Stalk et al. *Harvard Business Review*, May-June, p. 164.

Prahalad, C.K. (1993) The role of core competencies in the corporation. *Research Technology Management*, Nov/Dec, Vol. 36, Issue 6, p. 40.

Preece, R. (1994) *Starting Research*, 1st ed., London, Pinter Publishers.

Prigogine, I. and Stengers, I. (1984) *Order out of Chaos: Man's New Dialogue with Nature*. New York: Bantam Books.

Provan, K.G. and Gassenheimer, J.B. (1994) Supplier commitment in relational contract exchanges with buyers: a study of interorganizational dependence and exercised power. *Journal of Management Studies*, Vol. 31, No. 1, pp. 55-68.

Quinn, J.B. (1985) Managing innovation: controlled chaos. *Harvard Business Review*, May-June, pp. 73-84.

Quinn, J.B. and Hilmer, F.G. (1994) Strategic outsourcing. *Sloan Management Review*, Summer, pp. 43-55.

Quinn, J.B. (1999) Strategic outsourcing: leveraging knowledge capabilities. *Sloan Management Review*, Summer, pp. 9-21.

Ragatz, G.L., Handfield, R.B. and Scannell, T.V. (1997) Success factors for integrating suppliers into product development. *Journal of Product Innovation Management*, Vol. 14, No. 3, pp. 190-202.

Ramsay, J. (1998) Problems with empiricism and the philosophy of science: Implications for purchasing research, *European Journal of Purchasing and Supply Management*, Vol. 4, pp. 163-173.

Reason, P. and Rowan, J. (Eds.). (1981) *Human Inquiry: A Sourcebook of New Paradigm Research*. Chichester: Wiley.

Rich, N. and Hines, P. (1998) Purchasing structures, roles, processes and strategies: is it a case of the tail wagging the dog? *European Journal of Purchasing and Supply Management*, Vol. 4, No. 1, pp. 51-63, March.

Ring, P.S. and Van de Ven, A.H. (1992) Structuring co-operative relationships between organizations. *Strategic Management Journal*, Vol. 13, pp. 483-498.

Ring, P.S. and Van de Ven, A.H. (1994) Developmental process of co-operative interorganisational relationships, *Academy of Management Review*, Vol. 19, No. 1, pp. 90-118

Ritter, T. (1999) The Networking Company. Antecedents for Coping with Relationships and Networks Effectively. *Industrial Marketing Management*, Vol. 28, pp. 467-479

Ritter, T. (1999) Interconnected relationships: the effects of relationships on relationships. *Proceedings of the 15th Annual IMP Conference*, University College, Dublin.

Roberts, E.B. (1988) Managing invention and innovation. *Research and Technology Management*, January-February, pp. 11-29.

Robson, C. (1997) *Real World Research*, Blackwell, Oxford, UK.

Rogers, E.M. (1983) *Diffusion of Innovations*, New York, Free Press.

Rosenbloom, R. and Cusumano, M. (1987) Technological pioneering and competitive advantage: the birth of the VCR industry. *California Management Review*, Vol. 24, pp. 51-76.

Rothwell, R. (1972) *Factors for Success in Industrial Innovations from Project SAPPHO- a Comparative Study of Success and Failure in Industrial Innovation*, Brighton, Sussex, England, SPRU.

Rothwell, R, Freeman, C., Horsley, A., Jervis, V.T.P., Robertson, A. and Townsend, J. (1974) SAPPHO updated-Project Sappho phase ll. *Research Policy*, Vol. 3, pp. 258-291.

Rothwell, R. (1983) *Information and Successful Innovation*. British Library Report No. 5782: London.

Rothwell, R. (1992) Successful industrial innovation: critical success factors for the 1990s. *R&D Management*, Vol. 22, No. 3, pp. 221-239.

Rumelt, R.P. (1987) Strategy, economic theory and entrepreneurship. In D. Teece (ed.) *The Competitive Challenge*, Ballinger Books, Cambridge, MA.

Sako, M. (1992) *Prices, quality and trust: inter-firm relations in Britain and Japan.* Cambridge University Press, Cambridge, UK.

Sako, M., Lamming, R. and Helper, S. (1994) Supplier relations in the U.K. car industry: good news – bad news. *European Journal Of Purchasing And Supply Management*, Vol. 1, Issue 4, pp. 237-248.

Sanchez, R. and Mahoney, J.T. (1996) Modularity, Flexibility, and Knowledge Management in Product and Organisation Design. *Strategic Management Journal*, Vol. 17, (Winter Special Issue), pp. 63-76

Saren, M. (1984) A classification and review of models of the intra-firm innovation process. *R&D Management*, Vol. 14, no. 1, pp. 11-24.

Sayer, A. (2000) *Realism and Social Science*, London, Sage.

Schmookler, J. (1966) *Invention and Economic Growth*, Harvard University Press: Cambridge, MA.

Schumpeter, J. A. (1934) *The Theory of Capitalist Development.* Cambridge, MA: Harvard University Press.

Schumpeter, J. A. (1935) The analysis of economic change The Review of Economic Statistics, May (reprinted in 1944), *Readings in Business Cycle Theory*, Blaikston: Philadelphia.

Schumpeter, J.A. (1942) (Translated 1950) *Capitalism, Socialism and Democracy*, Harper and Row: New York.

Sei, S. (1996) Is technical innovation all? A hidden meaning of social relationships behind the product development stage in the Japanese automotive industry. In Nishiguchi, T. (ed.) *Managing Product Development*, Oxford University Press, Oxford.

Selznick, P. (1957) *Leadership in Administration.* Harper & Row, New York in H. Mintzberg and J.B. Quinn (1992) *The Strategy Process*, Prentice Hall.

Shaw, B. (1985) The role of the interaction between the user and the manufacturer in medical equipment innovation. *R&D Management*, Vol. 15, No. 4 (October), pp. 283-92.

Sheth, J.N. (1973) A model of industrial buying behaviour, *Journal of Marketing*, Vol. 37, pp. 50-56.

Silverman, D. (2000) *Doing Qualitative Research*, Sage: London.

Skinner, W. (1982) Technology and the manager. In M.L. Tushman and W.L. Moore (eds.) *Readings in the Management of Innovation*, pp. 464-475. Boston, Pitman.

Smart, B. (1992) *Beyond Compliance*, World Resources Institute, USA.

Smeltzer, L.R. (1997) The meaning and origin of trust in buyer-supplier relationships. *International Journal of Purchasing and Materials Management*, Winter, pp. 40-47.

Snow, C.C. and R.E. Miles (1992) Managing 21st century network organisations. *Organisational Dynamics*, Winter.

Snow, C. C., Miles, R. and Coleman, H. (1992) Managing twenty-first century network organisations, *Organizational Dynamics*, Winter, pp. 5-20.

Stalk, G. and Hout, T.M. (1990) *Competing Against Time, How Time-based Competition is Reshaping Global Markets*, New York, Free Press.

Stern, L.W. (1996) Relationships, networks and the three Cs. In Iacobucci, D. (1996) *Networks in Marketing*, Sage: USA.

Sykes, W. (1991) Taking stock: issues from the literature on validity and reliability in qualitative research. *Journal of the Market Research Society*, Vol. 33, No. 1, pp. 3-12.

Takeishi, A. (2001) Bridging inter- and intra-firm boundaries: management of supplier involvement in automobile product development, *Strategic Management Journal*, Vol. 22, pp. 403-433.

Takeuchi, H. and Nonaka, I. (1986) The new new product development game. *Harvard Business Review*, January/February, pp. 137-146.

Teece, D.J. (1986) Profiting from technological innovation: implications for integration, collaboration, licensing and public policy. *Research Policy*, Vol. 15, pp. 285-305.

Teece, D.J. and Pisano, G. (1994) The dynamic capabilities of firms: an introduction. *Industrial and Corporate Change*, Vol. 3, No. 3, pp. 537-556.

Teece, D.J. and Chesbrough, H.W. (1996) When is virtual virtuous? Organizing for innovation. *Harvard Business Review*, January-February, pp. 65-73.

Teece, D., Pisano, G. and Shuen, A. (1997) Dynamic capabilities and strategic management. *Strategic Management Journal*, Vol. 18, No. 7, pp. 509-533.

Thorelli, H.B. (1986) Networks: between markets and hierarchies. *Strategic Management Journal*, Vol. 7, pp. 37-51.

Tidd, J. and Trewhella, M.J. (1997) Organizational and technological antecedents for knowledge acquisition and learning. *R&D Management*, Vol. 27, No. 4, pp. 359-375.

Tidd, J. Bessant, J., and Pavitt, K. (1997) *Managing Innovation: Integrating Technological, Market and Organizational Change*, Wiley.

Tilly, C. (1994) The Time of States. *Social Research*, Vol. 61, No. 2, pp. 269-295.

Torvatn, T. (1996) *Productivity in Industrial Networks - Case Study of the Purchasing Function*, Norwegian University of Science and Technology, Trondheim

Trygg, L. (1991) *Engineering Design: Some Aspects of Product Development Efficiency*, Gothenburg, Chalmers University of technology.

Tsang, E. W. K. and Kwan, K-M. (1999) Replication and theory development in organizational science: a critical realist perspective. *Academy of Management Review*, Vol. 24, No. 4, pp. 759-780.

Tsekouras, G. (1998) *Integration, Organisation and Management: Investigating Capability Development*. Ph.D. Thesis, SPRU, University of Sussex.

Turnbull, P.W. and Cunningham, M. (eds.) (1981) *International Marketing and Purchasing: A Survey among Marketing and Purchasing Executives in Five European Countries*, MacMillan, New York, NY.

Turnbull, P.W. and Valla, J.-P. (eds.) (1986) *Strategies for International Industrial Marketing: The Management of Customer Relationships in European Industrial Markets*, Croom Helm, London.

Turnbull, P.W., Ford, D. and Cunningham, M. (1996) Interaction, Relationships and Networks in Business Markets: An Evolving Perspective, *Journal of Business and Industrial Marketing*, Vol. 11, No. 3/4, pp. 44-62

Ullrich, K. (1995) The role of product architecture in the manufacturing firm, *Research Policy*, Vol. 24, pp. 419-440.

Utterback, J.M. (1974) Innovation in Industry and the Diffusion of Technology. *Science*, Vol. 183, February 15, pp. 658-662.

Utterback, J.M. and Abernathy, W.J. (1975) A dynamic model of process and product innovation. *Omega*, Vol. 3, No. 6, pp. 639-656.

Utterback, J.M. (1979) *The Dynamics of Product and process Innovation in Industry*. In Hill, C. and Utterback, J.M. (eds), 1979.

Uzzi, B. (1997) Social structure and competition in interfirm networks: the paradox of embeddedness. *Administrative Science Quarterly*, Vol. 42, pp. 35-67.

Valla, J-P. (1998) *IMP1b Project: Managing Relationships in a Changing World.* April, unpublished document.

Van de Ven, A.H. (1976) On the nature, formation, and maintenance of relations among organizations. *Academy of Management Review*, Vol. 1 (October), pp. 24-36.

Van de Ven, A.H. and Ferry, D.L. (1980) *Measuring and Assessing Organisations*, New York, John Wiley.

Vanden Abeele, P. and Christiaens, I. (1987) De Klant als Generator van Innovatie in 'High-Tech' Markten - een Conceptuele en Empirische Studie (The customer as generator of innovation in high-tech markets - a conceptual and empirical study), *Economische en Sociaal Tijdschrift*, Nr. 1, pp. 27-56.

Van Echtelt, F. and Wynstra, F. (2000) Purchasing involvement in product development revisited: case studies at an office automation manufacturer. *Proceedings of the 9th IPSERA Conference*, 24-27 May, London/Ontario Canada, pp. 782-794.

Veryze, R.W. (1998) Discontinuous innovation and the new product development process. Journal of product innovation Management, Vol.. 15, pp. 304-321.

Von Hippel, E. (1976) The dominant role of users in the scientific instrument innovation process. *Research Policy*, Vol. 5, No. 3, pp. 212-239.

Von Hippel, E. (1978) A customer active paradigm for industrial product idea generation. *Research Policy*, Vol. 7, No. 3, pp. 240-266.

Von Hippel, E. (1985) *Learning from Lead Users In Marketing in an Electronic Age,* Buzell, R. D. ed.., 308-17, Cambridge, Mass.: Harvard Business School Press.

Von Hippel, E. (1986) Lead users: a source of novel product concepts. *Management Science*, Vol. 32, No. 7, July, pp. 791-805.

Von Hippel, E. (1988) *The Sources of Innovation.* Oxford: Oxford University Press.

Voss, C. (1985) The role of users in the development of applications software. *Journal of Product Innovation Management*, Vol. 2, (June), pp. 113-21.

Walter, A. and Ritter, T. (2002) IT Use in Relationships: A Value Driver? In *Proceedings of the 18th Annual IMP Conference*, September 5th-7th, ESC, Dijon, France.

Wasti, S.N. and Liker, J. K. (1997) Risky business or competitive power? Supplier involvement in Japanese product design. *Journal of Product Innovation Management*, Vol. 14, pp. 337-355.

Webster, F.E. and Wind, Y. (1972) A general model of organisational buying behaviour. *Journal of Marketing* 36, April, pp. 12-19.

Weick, K. (1979) *The Social Psycology of Organising Reading*, MA: Addison-Wesley, in Stacey, R. (1993) *Strategic Management and Organisational Dynamics.* Pitman Publishing.

Wensley, R. (1995) A critical review of research in marketing. *British Journal of Management.* Vol. 6, Special Issue, pp. 63-82.

Wernerfeldt, B. (1984) A resource-based view of the firm. *Strategic Management Journal*, Vol. 5, pp. 171-180.

Wheelwright, S.C. and Clark, K.B. (1992) *Revolutionizing Product Development*, New York, Free Press.

Whitney, D.E. (1988) Manufacture by design. *Harvard Business Review*, July-August, pp. 83-91.

Wilkinson, I.F. and Young, L.C. (1994) Business dancing – the nature and role of inter-firm relations in business strategy. *Asia-Australia Journal of Marketing*, Vol. 2, No. 1, pp. 67-79.

Williamson, O.E. (1975) *Markets and Hierarchies.* New York, Free Press.

Williamson, O.E. (1985) *The Economic Institutions of Capitalism*, Free Press, New York.

Wilson, D.T. and Jantrania, S. (1994) Understanding the value of a relationship, *Asia-Australia Marketing Journal*, Vol. 2, No. 1, pp. 55-66

Wilson, D.T. (1995) An integrated model of buyer-seller relationships. *Journal of the Academy of Marketing Science*, Vol. 23, No. 4, pp. 335-345

Winter, S. (1987) Knowledge and competence as strategic assets. In D. Teece (ed.) *The Competitive Challenge: Strategy and Organization for Industrial Innovation and Renewal*, pp. 159-184. New York: Harper & Row, Ballinger Division.

Womack, J.P., Jones, D.T. and Roos, D. (1990) *The Machine That Changed the World*, MacMillan International

Womack, J.P., Jones, D.T (1996) *Lean Thinking: Banish Waste and Create Wealth in Your Corporation*, Simon and Schuster

Wynstra, F. (1998) *Purchasing Involvement in Product Development*, PhD Thesis, Eindhoven Centre for Innovation Studies, Eindhoven University of Technology.

Wynstra, F. and ten Pierick, E. (1999) Managing supplier involvement in new product development: a portfolio approach. *European Journal of Purchasing and Supply Management*, Vol. 6, pp. 49-57.

Wynstra, F. and Van Echtelt, F. (2001) Managing Supplier Integration into Product Development: A Literature Review and Conceptual Model, *Proceedings of the 17th Annual IMP Conference*, Oslo, Norway.

Yin, R.K. (1989) *Case Study Research: Design and Methods*, 2nd edn., Newbury Park and London,Sage.

Zaltman, G., Duncan, R., and Holbeck, J. (1973) *Innovation and Organization*, New York, Wiley.

APPENDICIES

Appendix A: Interview Guide Exploratory Mini-Survey

A) Company background (Get an annual report beforehand to cover most of these)

- Could you tell me a bit about the background of the company?
  - when was it founded?
  - any major changes such as take-overs or mergers?
  - who owns the company now?
- What is your (personal) role and responsibility in the company?
- What is the total turnover world-wide (£)?
- How has that changed during the last 10 years?
- What is the number of employees world-wide?
- What are the major products of the company (in terms of profit, sales volume?)
- What are the core technologies of the company?

B) Identifying appropriate product development project

- Which product development project would you like to focus on?
- When was this product developed? - if still being developed, when is it due to be launched?
- Who initiated the development (the driver)?
- Is this product important to the company - why?
- Which product technologies are embedded in this product?
- Are you protective about the product and the underlying technology? - how?
  - Is it proprietary?

C) Discussing the role of innovation in process and marketing technologies in the NPD project

- Which process technologies were necessary to develop in this NPD project?
- At which stage were they developed?
- Did any process technologies actually enable the development of the product?
- Was it necessary to develop any marketing technologies? (e.g. distribution channels)
- If yes, at which stage?

D) Mapping network pool of technologies and identifying collaboration partner(s) (drawing)

Upstream:

- Could you identify which suppliers were involved in the development?
- Who were the most important?
- What components do they supply? - any process technology e.g. tool suppliers?
- Are there any other reasons why they are important? (Do they for instance possess particular capabilities or technologies?)
- Do they supply any other customers?
- Who are their major suppliers?
- What components do they supply?
- Are there any other reasons why they are important?
- Any important 3rd parties?
- What is the status of the main parties? (e.g. 'partners')

Downstream:

- Could you identify which customers were key to the development?
- Who were the most important?
- How did they contribute to the development?
- Are they buying from any of your competitors?
- What was their status? (e.g. 'partners')

Others:

- Any other companies that were important to this development, such as complementary manufacturers in other industries, research institutions, design houses, consultants?

- What was their status? (e.g. 'partners' or' strategic alliance')

E) Discussing collaboration activities

Identifying and Selecting:
- How did you identify the 'key actors' to be involved?
- Which criteria did you use to select them?
- Was the selection in any way hindered as a result of any 3rd party relationships? (explain the meaning of '3rd party' by referring to drawing)
- Did their 3rd party relationships enable their selection?

Timing:
- At which point in the process did the 'key actors' become involved (concept development, basic design, detail engineering, or pilot-production/start-up)?[134]
- Did any of these get involved at a later point as a result of their 3rd party relationships such as their suppliers, their other customers, or any other of their relationships?
- Did the existence of any 3rd party relationships mean that you wanted to get any of these involved at an earlier point?

Mobilising:
- Which measures did you use to mobilise these 'key actors'? - any risk/benefit sharing arrangements?
- Was it difficult to mobilise some of them because of their 3rd party relationships?
- Did any 3rd party relationships actually enable their mobilisation?

Assigning:
- Did you assign any people, such as resident design engineers, to the project?
- Was this constrained by 3rd party relationships?
- Which mechanisms did you apply to cope with the risk of people leaking information and knowledge to 3rd parties?
- Did 3rd party relationships actually enable this to happen?

Informing:
- How did you keep them informed them during the process? (e.g. communication of procedures and requirements, performance evaluation)
- Was the amount of information and knowledge being exchanged constrained by their 3rd party relationships?
- Which mechanisms did you use to cope with the risk of leakage of information and knowledge to 3rd parties?
- Did 3rd party relationships actually enable the process of information and knowledge sharing?

Synchronising:
- Did either you or they synchronise any procedures, processes, or systems?
- Was this process constrained by any 3rd parties?
- Did any 3rd party actually enable the synchronisation?

Co-ordinating:
- To what extent did you co-ordinate the relationships?
  - between 1st tier relationships?
  - across tiers?

[134] Use the term 'partners' or equivalent instead of 'key actors' if appropriate

Appendix B: Interview Guide One: Interviews with Focal Firm: Context

1) Company background
- Could you tell me a bit about the company?
- What is your (personal) role and responsibility in the company?
- What are the major products of the company (in terms of profit, sales volume?)
- What are the core technologies of the company?

2) Identifying appropriate product development project
- Do you have any ideas for a good product development project that we could focus on? – This has to have been completed quite recently, involved some extent of collaboration with suppliers and customers, and involved the application of a new product or process technology.
- When was the development of this product completed? - if still being developed, what stage is it at?

Concept Development	Product Planning/ Basic Design	Product/process engineering/ Detail Engineering	Pilot-Production / Ramp-Up

a) Screening Level of Collaboration:
- Were you able to choose your own suppliers?
- Were any suppliers involved in idea generation or concept development?
- Did you get involved at this stage with your customer or later?
- Was there any sharing of development costs between the main parties?
- Did the main parties provide full information to each other?
- Were any engineers specifically allocated to the project or exchanged?
- Was there any alignment of the main parties' technology development plans?
- Did you seek to jointly identify the root cause of critical technical problems with suppliers and/or customers?
- Was this product developed in response to a particular customer request or problem? -What was their request/problem?
- How innovative is this new product – Is it:

Revolutionary:	*Normal:*	*Incremental:*
transforming existing & new products	creating significant changes to existing & new products	creating only minor changes to existing & new products

3) Identifying underlying technologies
- What are the key product technologies that have been applied in this product?
- Have you had to develop new process technologies in order to produce this new product or did they exist already?
- Have these technologies been applied in other products yet?
- In how many products is this technology to be applied over the next 5 years?
- How innovative are the underlying technologies – Are they:

Revolutionary:	*Normal:*	*Incremental:*
transforming existing & new products	creating significant changes to existing & new products	creating only minor changes to existing & new products

- Does a common industry standard exist for these technologies?
- Does any of your competitors possess similar technologies, or technologies that perform the same function?

3) Project Performance: Process
- What were the *target* development costs of the product?
- What were the *actual* development costs of the product?
- What was the *target* development time of the product?
- What was the *actual* development time of the product?

4) Project Performance: Output
- What was the *target* cost per unit of the product?
- What was the *actual* cost per unit of the product?
- Has the development of the product resulted in any patents?
- Has the product, or the underlying technology, received any awards?

- If yes, which award(s)?
- What were the *forecast* sales in units of these products for the 1st year?
- What were the *actual* sales of these products the 1st year/to date?
- What was the external defect rate of the product in the 1st year/to date
- following launch i.e. percentage of units claimed to be defective, in PPM?
- Overall, how successful do you think this project was, according to the criteria given below:

	Very satisfactory	Satisfactory	Average	Unsatisfactory	Very unsatisfactory
In financial terms					
As a learning experience					

Comments:

5. Appropriability regime

- Have you taken any particular steps to protect this product and the underlying technology? - why?

patents	copyrights	trademark	trade secret

- Have any competitors attempted to copy the product (or any of the technology)?
- Have they been successful?
- How important is the history of the company in the development of the product?

6) Mapping industrial network and identifying collaboration partner(s) (drawing)

a) Upstream:
- Could you identify which suppliers were involved in the development?
- Who were you in most frequent contact with?
- What is the nature of the technology or components they supply?
- Are there any other reasons why they are important? (Do they for instance possess particular capabilities or technologies?)
- Do they supply any other customers?
- Who are their major suppliers?
- What components do they supply?
- Are there any other reasons why they are important?
- Any important 3rd parties?

b) Downstream:
- Could you identify which customers were key to the development?
- Who were you in most frequent contact with?
- How did they contribute to the development?
- Are they buying from any of your competitors?

c) Others:
- Any other companies that were important to this development, such as competitors, complementary manufacturers in other industries, research institutions, consultants?
- What was their status? (e.g. joint venture or strategic alliance)

Appendix C: Interview Guide Two: Interviews with Focal Firm: Collaboration Processes

1) Introduction

- Could you confirm if the map we drew the last time is accurate?

2) Collaboration Processes

a) *Uniting*

- How did you identify and choose the key suppliers to be involved in the project?
- Which criteria did you use to select these suppliers?
- How did the key customers get involved in the project? – Who approached whom?
- Why did you chose these customers and not others? – Was it your choice or theirs?
- To what extent did you end up with suppliers and customers you have worked with previously?
- Did you deliberately avoid any particular suppliers or customers?- Why?
- To what extent did your suppliers' or customers' other relationships affect your choice?
- Did you in any way try to co-ordinate the choice of the wider pool of suppliers and customers to be involved in the project? Example?

b) Timing:

- At which stage in the process did the key suppliers become involved?

Concept Development	Product Planning/ Basic Design	Product/process engineering/ Detail Engineering	Pilot-Production / Ramp-Up

- At which stage in the process did the key customers become involved?

Concept Development	Product Planning/ Basic Design	Product/process engineering/ Detail Engineering	Pilot-Production / Ramp-Up

- Did you seek to delay the involvement of any suppliers or customers? – Why?
- Did you deliberately want to involve any suppliers or customers at an earlier stage? – Why?
- To what extent did you seek to delay or advance the involvement of suppliers or customers you have worked with previously?
- Did you try to influence *at what stage* your suppliers were to involve their suppliers in the project? Example?

c) Mobilising:

- What were the arrangements for sharing of development costs with both suppliers and customers?
- Were the ground rules established at the beginning of the project? – Who took the initiative?
- Did you formulate the objectives at the beginning of the project? – Were they shared?
- Did you experience any difficulties motivating the key suppliers and customers to fully commit to the project? - Why?
- To what extent did your suppliers' or customers' other relationships affect the motivation of either suppliers or customers?
- To what extent was it easier or more difficult to motivate suppliers and customers you have worked with previously?
- Did you try to influence how your suppliers motivated their suppliers in the project? Example?

d) *Communicating*

- How were design ideas and concepts communicated with key customers?
- How were design ideas and concepts communicated with key suppliers?
- How did you communicate policies and procedures with suppliers during the process?
- How did you communicate policies and procedures with customers during the process?
- How was information concerning your performance as a supplier communicated with the customers?
- How did you communicate performance information with your suppliers?
- Did you hold back any of those types of information from suppliers or customers? – Why?

- To what extent did your suppliers' or customers' other relationships affect the amount of information being communicated?
- In the cases where you had previous experiences with suppliers or customers, how did that affect the amount of information being communicated?
- Did you try to ensure that the wider pool of suppliers and customers received the same information as your direct suppliers?
- Did you do anything to try to encourage communication amongst individual direct and indirect suppliers and customers or did you leave that to them? Example?

e) Exchanging human resources
- Did the key suppliers allocate any staff e.g. resident design engineers to the development team?
- Did the key customers allocate any staff to the development team?
- To what extent did this happen with suppliers and customers you have worked with previously?
- Did you avoid allocating staff from any suppliers or customers? – Why?
- To what extent did your suppliers' or customers' other relationships affect the amount of staff being allocated?
- Did you allocate any staff from any indirect suppliers or customers involved in the project? Example?

f) Synchronising:
- Did the key suppliers synchronise their development procedures to suit yours?
- To what extent did you seek to align your technology plans, or roadmaps, with key suppliers?
- Did the key customers synchronise their development procedures to suit yours?
- To what extent did you seek to align your technology plans, or roadmaps, with key customers?
- To what extent were the relevant adaptations already in place?
- Did you avoid synchronising with any suppliers or customers – Why?
- Was it a problem to synchronise with suppliers or customers who are involved with other companies - Why?
- Did you synchronise with any indirect suppliers or customers involved in the project? Example?

g) Problem Solving:
- How did you resolve critical technical problems with key suppliers during the project?
- Who or what had caused the problem?
- How did you resolve critical manufacturing or supply problems with key suppliers during the project?
- How did you resolve critical problems with key customers during the project?
- To what extent were these problems affected by your past experience with these companies?
- Was it a problem to agree on the root cause of problems with any suppliers or customers – Why?
- Were problems sometimes caused by suppliers or customers being involved with other companies - Why?
- Did you involve any indirect suppliers or customers in the problem solving process? Example?

3) Effect of collaboration activities on project performance

How do you think the way in which the collaboration activities were actually carried out in this project, affected a) project development cost, b) project development time, c) the eventual cost of the product, and d) the eventual value of the product? (please tick)

Key:
Negatively: -
Positively: +

	Project Development Cost		Project Development Time		Eventual Product Cost		Eventual Product Value	
	+	-	+	-	+	-	+	-
Uniting: Identifying and selecting the partners								
Timing: Deciding at which stage in the project to involve partners								
Mobilising partners: Establishing ground rules and arrangements for sharing of risks, benefits, and objectives								
Communicating with partners: Exchanging e.g. ideas and concepts, policies, and performance information								
Exchanging human resources with partners: Allocating e.g. resident design engineers to project								
Synchronising with partners: Aligning systems, procedures, plans and roadmaps								
Problem Solving: Resolving technical or supply problems								

Comments:

4) Improvement of collaboration activities

- Bearing the previous discussions about collaborating with a large group of parties for the development of new products, what is your vision for how you could ideally involve other companies in the best possible way?
- If you were to achieve that, would that involve any change in the collaboration activities we have discussed today?
- What would be the problems of realising these future changes?
- How would you cope with those problems?

Appendix D: Interview Guide Three: Interviews with Key Suppliers

1) Company background
- What is your (personal) role and responsibility in the company?
- What is the total turnover world-wide (£)?
- What is the number of employees world-wide?
- What are the major products of the company (in terms of profit, sales volume?)
- What are the core technologies of the company?

2) Mapping network pool of technologies and identifying collaboration partner(s) (drawing)[135]
- Looking at this network map, do you agree that these are the most important parties involved in the development?
- From the perspective of your company, are any key players missing?
- What are their roles in this project?
- On supply side: Do they supply any other customers?
- On customer side: What are their other major suppliers?
- Any other companies that were important to this development, such as complementary manufacturers in other industries, research institutions or consultants?

3) Collaboration Processes

a) *Uniting*
- How did you get involved in this project?
- How do you identify and choose which suppliers you wanted to involve in this project?
- Have you worked with these companies before?
- Did you deliberately avoid any suppliers? - Why?
- To what extent did your suppliers' or customers' other relationships affect which suppliers you wanted to involve?
- Did you in any way try to co-ordinate the choice of the wider pool of suppliers to be involved in the project?

b) Timing:
- At which stage in the process did you get involved?

Concept Development	Product Planning/ Basic Design	Product/process engineering/ Detail Engineering	Pilot-Production / Ramp-Up

- At which stage in the process did you involve your key suppliers?

Concept Development	Product Planning/ Basic Design	Product/process engineering/ Detail Engineering	Pilot-Production / Ramp-Up

- Did you seek to delay or advance your involvement in the project? - Why?
- Did you seek to delay the involvement of any suppliers? – Why?
- To what extent did your suppliers' or customers' other relationships affect at what stage they were involved?
- To what extent did you seek to delay or advance the involvement of any suppliers you have worked with previously?
- Did you try to influence at what stage your suppliers were to involve their suppliers in the project?

c) Mobilising:
- What were the arrangements for sharing of development costs with [the focal firm]? Any such arrangements with any of your suppliers?
- Were the ground rules established at the beginning of the project? – Who took the initiative? Any such arrangements with any of your suppliers?

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[135] This part as well as other parts of the interview schedule which address issues specific to either upstream or downstream relationships, may only be answered by respondents in the appropriate positions e.g. primarily Marketing people will be able to answer questions related to downstream relationships and *vice versa.*

- Did [the focal firm] formulate their objectives at the beginning of the project? – Did you share those?
- Did you experience any difficulties motivating your key suppliers to fully commit to the project? – Why?
- Did your suppliers' or customers' other relationships in any cases make it easier to motivate them?
- Was it easier or more difficult to motivate suppliers you have worked with previously?
- Did you try to influence how your suppliers motivated their suppliers in the project?

d) *Communicating*
- How were design ideas and concepts exchanged with [the focal firm] during the project?
- How were policies and procedures exchanged with [the focal firm]?
- How were design ideas and concepts exchanged with your suppliers?
- How were policies and procedures exchanged with your suppliers?
- How did [the focal firm] inform you about your performance during the project?
- How did you inform your suppliers of their performance during the project?
- Did you hold back any of those types of information from suppliers? – Why?
- Did you hold back any of those types of information from [the focal firm]? - Why?
- In the cases where you had previous experiences with your suppliers, how did that affect the amount of information being communicated?
- How did the extent of your previous experiences with [the focal firm] affect the amount of information being communicated between them and yourselves?
- To what extent did your suppliers' or customers' other relationships affect the amount of information being communicated?
- Did you do anything to ensure that the wider pool of suppliers received the same information as your direct suppliers?
- Did you do anything to try to encourage communication amongst individual direct and indirect suppliers or did you leave that to the suppliers?

e) Exchanging human resources
- Did you allocate any staff to the [focal firm] development team?
- Did this involve your suppliers?
- How did the extent of your previous experiences with [the focal firm] affect the amount of staff being allocated?
- To what extent did this happen with suppliers you have worked with previously?
- Did you avoid allocating staff from or to any suppliers involved in this project? – Why?
- To what extent did your suppliers' or customers' other relationships affect the amount of staff being allocated?
- Did you allocate any staff from any indirect suppliers involved in the project?

f) Synchronising:
- Did you synchronise your development procedures to suit [the focal firm's]?
- To what extent did you seek to align your technology plans, or roadmaps, with theirs?
- Did your key suppliers synchronise their development procedures to suit yours?
- Did any other key players align their technology plans, or roadmaps, with yours?
- To what extent were most of the relevant synchronisations already in place?
- Was it a problem to synchronise with suppliers who are involved with other companies? – Why?
- Did you avoid synchronising with any suppliers or [the focal firm]? – Why?
- Did you synchronise with any indirect suppliers involved in the project?

h) Problem Solving:
- How did you resolve critical technical problems with [the focal firm] during the project?
- Who or what had caused the problem?
- How did you resolve critical manufacturing or supply problems with [the focal firm] during the project?
- How did you resolve critical problems with your suppliers customers during the project?
- To what extent were these problems affected by your past experience with these companies?
- Was it a problem to agree on the root cause of problems with suppliers or [the focal firm] – Why?
- Were problems sometimes caused by suppliers or [the focal firm] being involved with other companies - Why?
- Did you involve any indirect suppliers or customers in the problem solving process? Example?

3) Effect of collaboration activities on project performance

How do you think the way in which the collaboration activities were actually carried out in this project, affected a) project development cost, b) project development time, c) the eventual cost of the product, and d) the eventual value of the product? (please tick)

Key:
Negatively: -
Positively: +

	Project Development Cost		Project Development Time		Eventual Product Cost		Eventual Product Value	
	+	-	+	-	+	-	+	-
Uniting: Identifying and selecting the partners								
Timing: Deciding at which stage in the project to involve partners								
Mobilising partners: Establishing ground rules and arrangements for sharing of risks, benefits, and objectives								
Communicating with partners: Exchanging e.g. ideas and concepts, policies, and performance information								
Exchanging human resources with partners: Allocating e.g. resident design engineers to project								
Synchronising with partners: Aligning systems, procedures, plans and roadmaps								
Problem Solving: Resolving technical or supply problems								

Comments:

Improvement of use of collaboration activities
- Bearing the previous discussions about collaborating with a large group of parties for the development of new technology, what is your vision for how you could ideally involve other companies in the best possible way?
- If you were to achieve that, would that involve any change in the collaboration activities we have discussed today?
- What would be the problems of realising these future changes?
- How would you cope with those problems?

Appendix E: Interview Guide Four: Interviews with Key Customers:

1) Company background

- What is your (personal) role and responsibility in the company?
- What is the total turnover world-wide (£)?
- What is the number of employees world-wide?
- What are the major products of the company (in terms of profit, sales volume?)
- What are the core technologies of the company?

2) Mapping network pool of technologies and identifying collaboration partner(s) (drawing)
- Looking at this network map, do you agree that these are the most important parties involved in the development?
- From the perspective of your company, are any key players missing?
- What are their roles in this project?
- On supply side: Do they supply any other customers?
- On customer side: What are their other major suppliers?
- Any other companies that were important to this development, such as complementary manufacturers in other industries, research institutions or consultants?

3) Collaboration Processes

a) *Uniting*
- How did you get involved with [the focal firm] in this project?
- How did the other key players get involved?
- Had you worked together with any of these companies before?
- Did you deliberately avoid any companies? – Why?
- To what extent did your suppliers' or customers' other relationships affect which key players you wanted to involve?
- Did you in any way try to co-ordinate the choice of the wider pool of companies to be involved in the project?

b) Timing:
- At which stage in the process did you get involved?

Concept Development	Product Planning/ Basic Design	Product/process engineering/ Detail Engineering	Pilot-Production / Ramp-Up

- Did you seek to delay or advance your involvement in the project? – Why?
- To what extent did your suppliers' or customers' other relationships affect at what stage they were involved?
- To what extent did you seek to delay or advance the involvement of any key players you have worked with previously?
- Did you try to influence at what stage any of the other key players, including [the focal firm] were to involve any of their contacts in the project?

c) Mobilising:
- What were the arrangements for sharing of development costs with [the focal firm]? Any such arrangements with any of the other key players?
- Were the ground rules established at the beginning of the project? – Who took the initiative?
- Did [the focal firm] or any other key players formulate their objectives at the beginning of the project? – Did you share those?
- Did you experience any difficulties motivating any of the other key players (including customers) to fully commit to the project? – Why?
- Did such relationships in any cases make it easier to motivate other key players?
- Was it easier or more difficult to motivate companies you have worked with previously?
- Did you try to influence how any key players motivated their relationships in the project?

d) *Communicating*
- How were design ideas and concepts exchanged with [the focal firm] during the project? Same way between you and other key players?
- How were policies and procedures exchanged with [the focal firm]? Same way between you and other key players?
- How did [the focal firm] inform you about your performance during the project?
- How did you communicate such information with other key players during the project?
- Did you hold back any of those types of information from other key players, including [the focal firm]? – Why?
- In the cases where you had previous experiences with key players, including [the focal firm], how did that affect the amount of information being communicated?
- To what extent did your suppliers' or customers' other relationships affect the amount of information being communicated?
- Did you do anything to ensure that the wider pool of companies received the same information as your direct contacts?
- Did you do anything to try to encourage communication amongst individual direct and indirect relationships or did you leave that to other companies?

e) Exchanging human resources
- Did you allocate any staff to the [focal firm] development team?
- Did this also involve any key contacts of yours?
- How did the extent of your previous experiences with [the focal firm] affect the amount of staff being allocated?
- Did you avoid allocating staff from or to any companies involved in this project? –Why?
- To what extent did your suppliers' or customers' other relationships affect the amount of staff being allocated?
- Did you assign any staff from any indirect relationships involved in the project?

f) Synchronising:
- Did [the focal firm] synchronise their development procedures to suit yours?
- To what extent did they seek to align their technology plans, or roadmaps, with yours?
- Did any other key players synchronise their development procedures to suit yours?
- Did any other key players align their technology plans, or roadmaps, with yours?
- To what extent were most of the relevant synchronisations already in place?
- as it a problem to synchronise with key players who are involved with other companies? – Why?
- Did you avoid synchronising with any suppliers or [the focal firm]? – Why?
- Did you synchronise with any indirect companies involved in the project?

h) Problem Solving:
- How did you resolve critical technical problems with [the focal firm] during the project?
- Who or what had caused the problem?
- How did you resolve critical manufacturing or supply problems with [the focal firm] during the project?
- To what extent were these problems affected by your past experience with [the focal firm]?
- Was it a problem to agree on the root cause of problems with [the focal firm] – Why?
- Were problems sometimes caused by [the focal firm] being involved with other companies - Why?
- Did you involve any indirect suppliers or customers in the problem solving process? Example?

3) Effect of collaboration activities on project performance

How do you think the way in which the collaboration activities were actually carried out in this project, affected a) project development cost, b) project development time, c) the eventual cost of the product, and d) the eventual value of the product? (please tick)

Key:
Negatively: -
Positively: +

	Project Development Cost		Project Development Time		Eventual Product Cost		Eventual Product Value	
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Communicating with partners: Exchanging e.g. ideas and concepts, policies, and performance information								
Exchanging human resources with partners: Allocating e.g. resident design engineers to project								
Synchronising with partners: Aligning systems, procedures, plans and roadmaps								
Problem Solving: Resolving technical or supply problems								

Comments:

Improvement of collaboration activities

- Bearing the previous discussions about collaborating with a large group of parties for the development of new technology, what is your vision for how you could ideally involve other companies in the best possible way?
- If you were to achieve that, would that involve any change in the collaboration activities we have discussed today?
- What would be the problems of realising these future changes?
- How would you cope with those problems?

Appendix F: Analysis and Interpretation of Intra-Company Perceptions of Collaboration Activities with Key Suppliers and Customer: Fuel Tank Development Project

	Project Engineering Manager	Commercial Co-ordinator	Quality/*Kaizen* Manager	Manufacturing Manager	Purchasing Manager
Respondent's role	Responsible for day-to-day running of project in focus, refers to Technical Manager.	Responsible for day-to-day running of J-Car UK interface.	Represents *Kaizen* department: acting as intermediate between manufacturing and project departments. Installs production facility and performs training function for manufacturing. Links mostly with tooling suppliers.		
Uniting	J-Car decided on plastic fuel tank, produced a specification and cost pack, and sent out for tender. ♣ Europart told by J-Car which key suppliers to use (nomination) - allowed to choose lesser value parts. ♣ Pricing set/negotiated by J-Car for key components: commercial problem ♣ When choosing its suppliers Europart sends out quotations but has good idea of outcome due to past experience. ♥ Europart do not look for suppliers who will only supply parts to Europart - looking at proven track record.	Europart won tender after J-Car sent cost pack to 3 or 4 potential suppliers. ♣ Key component supplier nominated by J-Car. Europart only allowed to choose lesser value items. ♣ Lack of ability for Europart to set price due to nomination – opens up for blaming. Also lack of ability to choose preferred local suppliers. ♣ Avoided known problem suppliers. ♣ Ended up with many previous suppliers. ♥ Some key components carried over from other J-Car projects.	♣ Not personally involved in choice of materials suppliers, but points out importance of J-Car nominating key suppliers e.g. negotiating prices with key Europart suppliers. Compared with other customers J-Car takes more control. ♣ Europart uses existing EuroPart Partner long-term tooling suppliers; ♥ Tooling suppliers become involved if they have sufficient spare capacity (and right price).	Europart became involved with J-Car through tendering process. Not personally involved in process, although provided information on supplier performance through managing operations. ♣ J-Car nominated key suppliers. Opportunity for Europart to present case for different supplier, but alternative must be substantially better than nominated source.	♣ Little latitude for Europart in choosing its key suppliers as these are nominated by J-Car. Only low value added suppliers chosen by Europart (where Europart seen as expert): chosen on quality, locality and price. J-MasterPart effectively part of J-Car: link to 3rd tier. Europart remote from Japanese suppliers. ♣ Did not avoid any particular suppliers or customers. ♣ Small proportion of child parts suppliers used before. ♠ Did not co-ordinate choice of wider pool of suppliers and customers: may nominate indirect suppliers.
Timing	Key component supplier involved in parallel with Europart: at design/concept stage (prior to nomination). ♣ Europart did not deliberately delay involvement of any suppliers or customers: too risky to overlook anyone once project reached UK potential. ♣ List of preferred suppliers for project: these would have been at least aware.	Key component supplier would have joined very early in J-Car Japan's project. ♠ Europart does not try to influence at what stage its suppliers involve their suppliers in the project: provide time schedule for part requirements.	Tooling supplier became involved right from the start, especially the EuroPart Partner internal M&V. ♠ Limited attempt to influence tooling supplier's timing of involving their suppliers; performance monitoring may highlight potential problems	Key suppliers became involved through concept stage; J-Car involved Europart same stage i.e. from first initial approach: ♣ Europart needed support/prices from supplier base in producing quote.	Nominated suppliers involved at design stage: managed in Japan. Believes Europart was involved too late by J-Car, causing problems e.g. not being aware if design has been fixed. ♠ Europart suppliers involved asap. Did not try to influence when their suppliers were to involve their suppliers.
Mobilising	Tooling and prototype costs incorporated into piece price or reimbursed by J-Car. Key milestones part of cost pack incl. requirements, market information etc. Ground rules established at nomination but do not believe it is ever formalised. Motivating of suppliers not normally a problem due to the volume, value and prestige of the business. ♣ Europart followed J-Car's rules and objectives, setting targets accordingly.	Overall development costs usually incorporated into piece price. Europart rarely pay suppliers lump sum for development cost apart from tooling cost. J-Car ultimately pays for tooling: claim back from J-Car. No difficulties motivating key suppliers to commit to project as they want the business. Also good relationships help motivation. ♠ Would like to try to influence how Europart's suppliers motivate their suppliers in project, but do not have resources.	Respondent has limited input into arrangements for sharing of development costs and ground rules (projects). ♥ Europart finances tooling, enabling it to use it elsewhere if necessary.	♣ J-Car 's master timing plan was broken down by Europart into own project timing plan, however, as suppliers follow J-Car 's plan and timings this creates problems for Europart operations. ♣ Lack of ownership of supply base, due to nomination, causes problems: Europart effectively receives a handling charge but no profit.	Development costs financed by J-Car . Some packaging costs shared with supplier. Europart formulated project objectives at beginning of project. No real problems motivating most suppliers due to prestige and volume. ♣ J-MasterPart did not recognise Europart as customer: problem. Europart de-motivated due to J-Car's dual sourcing, sometimes favouring other supplier. ♣ Some suppliers motivated as they can see historical increase in business. ♠ Did not try to influence how indirect suppliers were motivated; difficult enough to involve 2nd tier: resource constraints.
Communicating	All requests go to J-Car UK who do not	Europart has supplier guidelines which are	Europart communicates its environmental,	Communicate supplier delivery	J-Car 'Are You Ready' reviews. All

	always make own decisions: requests forwarded to Japan, R&D centre or HQ (Europart no direct involvement). Supplier performance communicated through supplier development: delivery & quality. ♣ Europart issue supplier guidelines, terms and conditions when issuing orders/quotations: J-MasterPart's conditions may ultimately apply due to close relationship with J-Car. ♣ Terms & conditions known from previous programmes. ♠ Communication with wider pool of suppliers responsibility of 2nd tier. Europart may intervene beyond 2nd tier if wanting to ensure suppliers are on critical path.	issued when issuing orders. ♣ Arguments over whose terms and conditions to apply due to J-MasterPart's relationship with J-Car. ♣ Europart experienced difficulties in flow of information: may be circumvented. ♠ Europart would not communicate to 3rd tier.	health and safety policies to suppliers, as do J-Car with Europart: checks suppliers' policies/capabilities by issuing questionnaire. Suppliers receive performance ratings. ♦ Respondent unaware of information being withheld, believing it should be open e.g. enabling joint VA/value analysis (involving suppliers and J-Car) ♠ Respondent unaware of Europart communicating beyond direct suppliers unless there is a concern.	performance information: more forgiving during development, due to number of changes. ♥ Volume analysis (scheduling) information sent directly to indirect suppliers. ♣ Information on Europart's real operating performance withheld from suppliers and J-Car, to win business.	suppliers go through Europart's supplier approval process, including supplier guidelines. Also quarterly review of all suppliers. Europart struggles with time lack between J-Car UK and J-Car Japan. ♦ Would withhold information on individual supplier performance from other suppliers. During bidding information is more tight. ♣ Europart felt out of loop when design changes occurred, annoyed by late notices. ♥ Suppliers having relationships with Europart's competitors seen as informal way of obtaining information on competitors: not seen as problem.
Exchanging knowledge	Design change information normally passes through Europart's commercial department to engineering and purchasing, then forwarded to suppliers. J-Car makes specific requests rather than airing ideas for discussion. ♦ During design/concept stage Europart only given relevant information, J-Car avoiding to provide details of whole vehicle. ♥ J-Car UK may be unaware of changes, made by its R&D department in Japan, discussed with J-MasterPart: informal route of information for Europart.	Europart forwards J-Car's drawings to suppliers but left J-MasterPart and J-Car to exchange design issues, such as drawings, between themselves without Europart becoming involved.	Respondent has visited suppliers to identify and root out processes which may cause potential problems. Suppliers seen as happy to listen to Europart's suggestions if useful. ♦ Europart very careful not to provide J-Car with too much technical know-how as they have very close relationship (internal?) with another supplier. J-Car very keen to receive copies of documents detailing Europart's processes and technology. Recognises it is part of J-Car's learning culture: learning from range of suppliers/ assisting e.g. in simplifying designs. Works both ways	Knowledge on test equipment exchanged: Europart's unique system: shared with J-Car but not suppliers. ♦ Suppliers' and J-Car's other relationships did not affect manufacturing but knowledge related to Europart's core technology was withheld when J-Car was over-interested. ♣ Previous experiences with suppliers and J-Car would not affect amount of engineering or market knowledge being exchanged by manufacturing.	Drawings issued to Europart from J-Car Japan to J-Car UK and forwarded to Europart and thence suppliers. Also technical and material specifications exchanged: seen as way of communicating end customer/consumer needs down supply chain. ♦ ♣ Europart provide suppliers with all technical information: no real knowledge exchange limitations.
Exchanging human resources	Europart had resident engineer (from its HQ) on J-Car Japan's development team: informed of requirements and consulted on technical issues. J-Car did not allocate staff to Europart's team. No exchange of resident engineers between Europart and 2nd tier: basic design would have been done within Europart.	J-Car did not allocate staff to Europart's development team	Not aware of any residents for this project, although Europart has supply development engineer assigned to assist suppliers. One resident engineer was allocated for 1st product application to J-Car Japan. Seen as important then as Europart was starting up. Main constraint is resource, needing sufficient internal people.	Not aware of any resident engineers.	J-MasterPart allocated resident engineers to J-Car's development team, not Europart's: constructing drawings. Not seen as necessary to allocate more staff due to Europart's limited involvement in J-Car's design. ♠ No indirect suppliers or customers involved in project.

Synchronising	J-MasterPart set in its ways and a global player: adapts to J-Car rather than Europart: Europart can merely inform it of its requirements. Europart would not align its technologies to any key suppliers, but sees technical collaboration with key supplier as possibility. ♣ Experience from previous projects allowed Europart to look out for road blocks and pitfalls.	Do not think key suppliers synchronised development procedures. ♣ Relevant adaptations with suppliers already in place because of previous project experience, thus much more aware of their systems, and any pitfalls that Europart had experienced before.	J-Car issued a timing programme: Europart synchronised all activities accordingly. Not aware of any technology alignment.	Key suppliers synchronised phase builds and test builds procedures. ♣ Relevant adaptations all in place: matter of timing. ♣ Did not avoid synchronising with anyone. ♣ Suppliers involved with many customers, managing several projects: affects priorities and causes Europart to fail to meet phasing. ♣ Suppliers responding to J-Car's demand, rather than Europart's, means that suppliers end up with different standards and different performance objectives.	Key suppliers do not always synchronise development procedures– supposed to: suppliers thus not always ready in time for production. Suppliers all the way down the supply chain must align with J-Car, although possibly large suppliers do not. Future technology development seen as Europart HQ responsibility. ♣ Most physical adaptations in place from previous project. ♣ Not seen as problem to synchronise with suppliers involved with other companies: Europart insist on having its systems adhered to or combine systems. ♠ Do not synchronise with indirect suppliers.

NB: Different codes/bullets indicate type of network effect:

♣: Network as constraint: Network dependencies including path, technological, and admin./logistical.

♦: Network as constraint: loss of control: Dissipation of knowledge and technology to third parties

♥: Network as enabler: Network access strategy/networking

♠: Network as enabler: Intervention and dissemination/delegation strategies

FC: Focal Company

Appendix F Continued: Analysis and Interpretation of Inter-Company Perceptions of Collaboration Activities: Fuel Tank Development Project

	J-Car UK	JMasterPart	ToolMaster	EuroPart Partner	J-Car Commerce
Respondent's Role	From New Model Parts Development, which introduce new products/parts with suppliers. Personal role to manage project from drawing to mass production, project managing quality and cost through development e.g. involving tooling modifications and trial builds.	A) Sales/Project Manager, J-Car Sales Department. Responsible for business development i.e. winning business with J-Car, including price negotiations, quality and delivery aspects; preparation of parts. B) J-MasterPart OE Sales Executive. Respondents have limited knowledge of activities in Japanese HQ and R&D.	Operations/Works Director and Managing Director MD: Overall responsibility for the two sides of the business i.e. blow moulding and injection moulding.	Programme Manager: leading the J-Car product line programme for mass production in the United States, UK and Brazil, incl. technical issues, financial issues etc..	Team Leader in sales department dedicated to UK tier one suppliers. Specialise in sourcing of fuel tank and chassis parts. Minimal design and development involvement
Uniting	J-Car Cost & Sourcing or R&D team choose suppliers (R&D chose EuroPart). Use formal performance monitoring system. ♣ EuroPart chosen due to existing supply in other regions i.e. a global supply contract and history/experience from 1st car application. Viewed as critical supplier (technical complexity/safety of fuel tanks). ♣ Did not avoid anyone when choosing tank supplier. ♥ J-Car positive towards EuroPart's close links with J-Car R&D in Japan and rel. with EuroPart US; EuroPart supplying other customers is positive: learn from mistakes with others & shows they are good suppliers. ♠ J-Car tried to co-ordinate wider pool of suppliers by specifying J-MasterPart and J-Car Commerce (due to history, 'a safe pair of hands', and global supply contract). Horizontal co-ordination with J-MasterPart and EuroPart only due to their particular problem.	J-MasterPart became involved in project as result of development in Japan. J-MasterPart UK subsequently sent off quotation etc. ♣ J-MasterPart Japan chose pump suppliers, sending out for tender or used existing suppliers. ♣ 'A controlled situation' i.e. J-MasterPart a controlled supplier of J-Car's (however control does imply effect). Limited choice of suppliers as European suppliers quality standards are lower than those of Japanese counterparts, which made J-MasterPart a natural candidate.	Quality of material most important criterion for ToolMaster. ♣ Relation with EuroPart as ToolMaster already worked for EuroPart Partner's base in Yorkshire, have known EuroPart Sales Director for years (works for both EuroPart and EuroPart Partner). Competition after initial intro. ♣ ToolMaster uses preferred long-term suppliers and did not avoid anyone: good relationships built up over time; do not shop around very often, unless suppliers are not performing. ♥ Suppliers' or customers' other relationships make no difference with regard to whom ToolMaster wishes to involve. ♠ No co-ordination of choice of wider pool of suppliers to be involved in project. ToolMaster's choice where to source material.	♥ J-MasterPart and J-Car Commerce nominated by J-Car	♣ Suppliers' or customers' other relationships not seen as relevant due to supplier specification (and thus effectively is). ♣ J-Car specify 2nd tier suppliers: do not trust non-Japanese suppliers' capabilities.: a *fait accompli*. J-Car provided drawing and list of child part suppliers, specifying key (Japanese) suppliers and offering JC as conduit. ♣ J-Car co-ordinate all the Japanese suppliers by controlling complex parts, 'free-issued' to J-Rubber 1 or J-Rubber 2; they assemble and sell on - 'keeping it in the family' i.e. controlling as many costs as possible within J-Car Group. ♣ JC would have avoided J-Rubber 2 if choice, viewed as 'pain in the neck'. UK companies last priority: inflexible delivery.
Timing	Fuel tank design was virtually completed between JapComp and J-Car J-Car Japan before EuroPart was even nominated. EuroPart basically copied that design but with own spec. EuroPart Partner involved before EuroPart (with J-Car J-Car Japan), making the drawings. ♣ J-Car did not delay or advance timing, EuroPart got involved as soon as drawings were set. EuroPart had finished tooling before smaller suppliers were even nominated. J-Car UK received drawings same time as other suppliers; suppliers collaborating with J-Car Japan in Japan; involved even earlier. ♠ J-Car UK made sure, as part of QAV, that suppliers' suppliers are involved and checked.	Car was released first in Japan i.e. design was already completed in Japan. J-MasterPart Japan became involved during concept development, J-MasterPart UK during detail engineering/pilot production/start-up. ♣ Some cross-ownership between Toyota and J-MasterPart (historical link), but respondent does not believe that explains closeness of link. ♣ Did not deliberately delay or advance J-MasterPart's involvement in project. ♥ No effects of suppliers' or customers' other relationships on timing. ♠ Did not try to influence at what stage suppliers were to involve their suppliers in the project: all based on customer's schedule, cascading information, only influence is to convey requirements.	ToolMaster became involved, by EuroPart, at very early stage for tooling, at concept development. ToolMaster involved its suppliers at tool design stage, much later on, when specification was ready, at detail engineering. ♣ Did not seek to delay involvement of suppliers: ToolMaster responds immediately to any EuroPart demands and involve suppliers the minute ToolMaster is ready to begin sourcing materials. ♣ J-Car may visit ToolMaster directly to help e.g. for leverage when buying. ♥ Suppliers' or customers' other relationships did not affect at what stage they became involved. ♠ Did not try to influence when their suppliers were to involve their suppliers: their problem.	Respondent believes EuroPart Partner and J-MasterPart became involved at same time, although suspects J-MasterPart became involved earlier as they were more closely involved in project.	♣ JC became involved at 'D1 Design Stage' i.e. shortly after drawings were issued to EuroPart/knew which parts to use. Knew from previous project that parts would take long to source from Japan and thus urged early involvement. ♣ JC's suppliers became involved from the very start (before JC) having already been nominated by J-Car Japan to supply domestically. They are specialists in their field and their parts will thus be designed in close collaboration with J-Car. ♠ JC did not try to influence at what stage those two Japanese suppliers involved their suppliers – would not supply chain manage it thus far as a general rule.
Mobilising	Respondent unsure of split for sharing of development costs, but believe mostly at EuroPart's expense, including testing. Suppliers' development work shows their capability. J-Car UK may order some prototypes (and pay). Ground rules established in terms of general purchasing agreements, establishing responsibilities etc.. EuroPart had one already. Not seen as formal contract as such. Suppliers have to show action plan at beginning including costs, aims and targets, quality, delivery, performance, milestone events being monitored	No development costs being exchanged with EuroPart, but already delivered for Japan product line. All commercial discussions with J-Car, including tooling costs. Ground rules were established after being selected, at a 3-way meeting with J-Car UK, J-MasterPart and EuroPart, on J-MasterPart's initiative. All objectives fairly well understood, having been disseminated from J-Car. ♣ No difficulties motivating key suppliers to fully commit to project but can be a problem motivating tool makers. Re. relationship	EuroPart financed tooling. If EuroPart wanted modifications ToolMaster re-quote. No other development costs. Can be discussions/arguments re. tooling design, although decisions remain with EuroPart and J-Car; ToolMaster only make suggestions, realising that changes may affect whether parts have to be re-tested. ToolMaster's responsibilities established during standard quotation process. Different situation with ToolMaster suppliers who supply raw material: no costs to share.	Development costs, prototype tooling costs, engineering costs etc. were quoted and agreed with J-Car. J-Car could thus have gone to another supplier for production, but EuroPart Partner quoted for that also and secured the business: costs for production tools, blow mould machines etc. included into mass production quote. Ground rules have been quite clear in terms of who should be responsible for what. Objectives also clearly defined with J-Car about EuroPart Partner's responsibilities and their expectations and specifications.	Believes J-Car Japan financed all development costs via piece price i.e. ultimately J-Car pay. Not aware of arrangement with two Japanese suppliers JC rely on J-Car Japan to project manage but equally rely on itself and EuroPart to project manage J-Car project management i.e. mutual project management. ♣ Motivation problems with one Japanese supplier being inflexible due to lack of clout but EuroPart would be worse off on their own with this supplier, as J-Car is important customer for this supplier. ♣ Ground rules established at beginning of project in terms of EuroPart/JC lessons from previous project

	through QAV. ♣ Only motivation problem was issue with J-MasterPart and EuroPart – J-MasterPart had own agreement with J-Car Japan: seen as unusual situation. ♥ EuroPart dedicated much effort to project, possibly because of little other business at the time and received much support from EuroPart Partner US and Europe. ♠ Co-ordination only in terms of making sure EuroPart's suppliers were involved.	between J-MasterPart and EuroPart, J-MasterPart do not see EuroPart as their customer but simply as a delivery point. J-MasterPart view J-Car as customer: seek to fulfil J-Car's requirements not EuroPart's. But all three parties have to agree issues e.g. quality problems. ♥ Suppliers' or customers' other relationships did not make it easier to motivate them. However, J-MasterPart initially not motivated to supply its direct (supply) relationship i.e. EuroPart, focusing on its relationship with J-Car.	EuroPart formulated their objectives at the beginning of the project in terms of delivery dates and annual requirements: ToolMaster act accordingly. ♦ ♣ Experienced no difficulties motivating key suppliers to fully commit to project – must be committed.: not network effect ♥ Suppliers' or customers' other relationships did not affect motivation. ♣ ToolMaster and its suppliers are self-motivated. Motivation not seen as an issue. ToolMaster supplier relationships very close: at the end of a telephone. Steel tooling and plastics suppliers much bigger than ToolMaster. ♠ Did not try to influence how suppliers motivated their suppliers in the project: do not even know who they are.	Motivation: good relation with J-Car (Japan) and no real problems from a development point of view.	were carried over - being aware of everyone's parameters. ♣ Responsibilities communicated with Japanese supplier by JC's office in Japan, informing of annual requirements: JC have learnt from experience that suppliers need monthly/yearly requirements, planned ramp up and start of production, asap. ♣ Both easier and more difficult to motive suppliers JC had worked with previously. Two Japanese suppliers were much more supportive for 2nd application than 1st. EuroPart had met them in Japan for 1st application and gained respect consequently. ♠ Did not try to influence how JC suppliers motivated their suppliers: if problems had occurred JC would have consulted J-Car rather than directly contacting suppliers in Japan.
Communicating	Design ideas and concepts communicated via EuroPart Partner design engineer working in Japan with J-Car Japan. Info. did not always go directly to EuroPart but would go through J-Car UK. Action/project plan communicated to suppliers at start of project; suppliers monitored through QAV. Also informal visits for checking parts, discussing problems. Milestone events increasingly frequently towards end. ♦ ♣ No info. withheld by J-Car UK, particularly because tank was already established in Japan and US developments were 3 months ahead, thus knew EuroPart was to be involved and needed all info. possible. ♠ J-Car UK would try to encourage EuroPart to pass on info. but neither formally nor following up. Had close links with two key suppliers. ♠ Not seen to be in J-Car UK's interest to encourage communication amongst suppliers of different parts/horizontally.	All design details come from J-Car. J-MasterPart received pump drawings from J-Car. J-MasterPart received a supplier report from EuroPart, focusing on delivery performance. Policies and procedures were exchanged at three 3-way meetings where e.g. delivery issues were discussed. Some tension at the start. Following those meetings relationship between EuroPart and J-MasterPart has been quite good. J-MasterPart try to support EuroPart as much as possible. ♦ Design details were held back from EuroPart because they were not seen as part of the process and fears that they might use information to develop own pump. ♣ J-MasterPart has limited experience with European suppliers so no effect on amount of information being communicated.	Involved in exchange of drawings with EuroPart. Interact with EuroPart if design features need altered; not exchanged with ToolMaster's suppliers, as they only supply raw material: only receive spec. forwarded from EuroPart. Policies and procedures exchanged with EuroPart through their supplier manual and ToolMaster's terms and conditions; same procedure with ToolMaster suppliers. ToolMaster did not receive formal performance info. during the project (did during production) but if delivery date not met ToolMaster would receive a letter. Timing plan issued every week by ToolMaster to keep EuroPart informed of progress but EuroPart do not usually monitor progress. ♦ No secrets, including 'strategic knowledge', from suppliers or customers: nothing to withhold in any way i.e. ToolMaster communicate as much as possible with EuroPart and suppliers. ♦ ♣ Some customers have tried to ask for cost breakdowns i.e. open book costing but have little idea of part costs so ToolMaster could tell them any price. ♠ Did not seek to communicate with wider pool of suppliers.	EuroPart Partner's design engineers had design review meetings with J-Car designers and fuel tank engineers, over period of 2 - 3 weeks. CAD engineering done by EuroPart Partner in Europe working directly with J-Car. App. three monthly meetings in Japan but always dyadic. EuroPart Partner had very limited communication with J-Car UK. EuroPart Partner's regional plants e.g. EuroPart communicated with J-Car's regional plants e.g. J-Car UK. Clear separation between the two situations i.e. EuroPart Partner had few problems with e.g. J-MasterPart, this was a manufacturing rather than development issue. Focal point of discussion was always J-Car who were leading all these activities; EuroPart Partner hardly met J-MasterPart during development. EuroPart Partner received very limited supplier performance feedback during the project, other than informally at meetings, less than in other projects but no major problems. Had app. monthly programme status reports and test status reports. ♠ No team meetings involving wider group of suppliers, but this happens now in other programmes.	Few design ideas and concepts exchanged with EuroPart, communication between JC and EuroPart/JC and J-Car UK tended to be of supply nature. JC normally communicated with Japanese suppliers through their Japanese HQ, these often knew of design changes before information reached EuroPart and JC. Cost system very transparent between JC and J-Car Japan - J-Car negotiated JC's EuroPart price/margin. Policies and procedures exchanged with EuroPart by JC referring to the deal with J-Car, incl. price, delivery agreements etc. Performance feed-back informal, although 'are you ready?' sheets in place. ♦ ♣ Did not withhold information on performance, design ideas and concepts and polities from suppliers and would not withhold any info. from EuroPart or J-Car. ♣ JC's relationship with J-Car affected communication as EuroPart was circumvented. EuroPart tried to implement formal performance feed-back in previous project but realised the uniqueness and slowness of supply and communication route. ♣ Experience from previous project enabled extent of info. sharing, understanding each other's requirements better e.g. relating to continuous replenishment requests from Japan - an initial learning curve. ♥ JC forwarded questions from EuroPart to J-Car UK to seek extra information e.g. from R&D which EuroPart would not always be able to receive. ♠ JC relies on its suppliers to communicate with sub-suppliers.
Exchanging knowledge	Much tank development performed in Japan between JapComp and J-Car R&D (J-Car Japan): JapComp designer made original drawing for J-Car Japan which the EuroPart designer subsequently used as basis, using EuroPart's slightly different technology. End customer/consumer demand info. not relevant as they would not be interested in this type of component, main issue is regulation/ safety and functionality. ♣ Development experiences from EuroPart US carried over. ♥ J-Car learn from EuroPart's mistakes with other customers and also share facilities (with Other VM: blow moulder).	Does not know about exchange of other technical engineering or consumer/end customer demand knowledge with EuroPart as this concerns J-MasterPart Japan.	Knowledge exchange primarily concerns manufacturing of tool as more skill is attached to it, which is why EuroPart use ToolMaster. Tool manufacture process is ToolMaster's business; EuroPart do not need to know that, although may if they want. Tooling knowledge not discussed with ToolMaster suppliers. Only customer need or demand knowledge concerns delivery, spec. and quality requirements: from EuroPart not J-Car. ♦ No engineering or market knowledge withheld from suppliers, but only receive spec for its part, do not see actual, specific, fuel tank. Believe everyone would benefit from more insight re. production of part, but		JC do not become involved in exchanging technical engineering knowledge apart from forwarding. JC did not know much about end customer need or demand knowledge same with JC's suppliers. ♦ JC now dealing with other customer, competitor of EuroPart, for next tech. application. This new customer is UK part of the Japanese fuel tank supplier, but UK factory has only recently expanded into fuel tanks. Respondent believes EuroPart were probably used as information was shared widely for this project which has made this tech. common in Japan.

			no problem in this case.		
Exchanging human resources	Believes there were two EuroPart Partner resident engineers in Japan making drawings with J-Car Japan. J-Car UK not involved in design so little relevance of resident design engineers with J-Car UK. ♠ J-Car UK occasionally allocate people to sort out production problems at suppliers.	No staff allocated by J-MasterPart to EuroPart's development team but engineers on site in J-Car Japan (J-MasterPart Japan). Little knowledge of this activity.	No staff allocated by ToolMaster to EuroPart development team, but ToolMaster is small company and works as a team; everybody is involved, particularly management. Only human resource link with suppliers is via sales/technical reps. In previous project ToolMaster agreed to allow designer to work within ToolMaster for some time, jointly designing the part. Viewed as way to get superior part and costs down.	EuroPart Partner sales and marketing office (including engineers) in Japan, close to J-Car; would visit J-Car for meetings, acting as interface to EuroPart Partner, Europe. No J-Car development team existed: core knowledge and experience in Europe. Believes it is different now. Seen as very important due to distance but often a cost issue and depends on nature of relationship. J-Car asked for resident designers in Japan but EuroPart Partner preferred to keep main expertise in Bonn.	JC staff not allocated to EuroPart's development team. A couple of people within JC manage the relationships. JC Japan allocate to J-Car's base.
Synchronising	EuroPart and J-Car UK synchronised project management plans. Alignment of tech. plans: believes everyone will end up going in same direction due to legislation. EuroPart may revert to steel technology due to waste disposal problems with plastic: legal judgement pending. Everyone tries to follow best weight and cost reduction, regulation etc., whatever works out is way everyone will tend to go. Tech. used with other customers may be offered to J-Car and if it works they might use it (not for fuel tanks). ♣ Most synchronisations already in place from previous project. Problems with 1st car project, resulted in QAV system being implemented. ♣ Problems to synchronise with large suppliers unwilling to change own systems, which J-Car has to accept. J-MasterPart also slightly unwilling e.g. to translate their plans from Japanese. J-Car a very important customer to EuroPart (30-40%) so no excuses.	Delivery but not development procedures were synchronised. Future technology plans of EuroPart and J-MasterPart fairly separate. Other key players may align their technology plans with J-MasterPart's but J-MasterPart UK not involved. J-MasterPart Japan would align to J-Car Japan.	ToolMaster synchronise with EuroPart, not *vice versa*, basically do what they are told (follow EuroPart's timing plan), because EuroPart is customer. Same with ToolMaster suppliers. No key players aligned technology plans with ToolMaster. ♣ Most relevant synchronisations already in place: quality manuals and procedures were laid down already. ♣ Not a problem to synchronise with suppliers involved with other companies ♥ Did not avoid synchronising with any suppliers or EuroPart.	No alignment or synchronisation of technology development plans. Global requirements based on legal and safety requirements and European guidelines: all auto manufacturers know future requirements. Vehicle manufacturers will ask suppliers how they intend to manage requirements and their technology approach. EuroPart Partner has own technology strategy: this is used for convincing customers of products' ability to meet requirements, confidence levels etc. ♠ Overall programme management performed by J-Car: EuroPart Partner responsible for own system delivery, co-ordinate most suppliers re. timings etc. (although not J-MasterPart) i.e. cascading. J-MasterPart effectively separately programme managed. ♣ No approach from J-Car telling EuroPart Partner how to change technology.	

Appendix F Continued: Analysis Matrix Used for Intra-Case/Intra-Company Analysis: Base Station Equipment Project

	Group Quality Manager	Programmes Director	Programme Manager	Sales Manager
Respondent's role	Chair global quality forum. Roles in customer/market quality, system quality, MPI & ISO9000, suppliers.	Overall programme/project responsibility.	Act as focal point for communication between FC and customer. Project planning responsibility. Took over from previous programme manager after initial concept phases.	Main site interface with key customers. Commercial responsibility. Liase with ECM and FC.
Uniting	3 part approval (vendor assessment) process for suppliers, depending on type of supplier (suppliers of design critical parts production capability assessed). Production supplier decision Purchasing & cost led. Internal suppliers involved per default for prototyping. ♣ Used existing suppliers ♦ FC changed supplier in the past when discovering it was supplying competitor – depends on individual supplier's degree of confidentiality (exceptional). Do not want competitors to see FC prototypes exposed at suppliers. ♣ TM specify some FC suppliers (approved list) – if FC wish to use supplier not on list it must undergo a qualification process. ♥ FC consulted TM re. its assessment of one of its suppliers. ♠ Some specification of sub-suppliers (within TM's spec./approval list). ♠ FC suggested to TM in the past that it unite FC and cabinet supplier to co-ordinate design, but has not happened. Similar ideas with FC suppliers but not materialised (concept stage involvement would be required).	Production suppliers only just becoming involved. FC do not have an approved suppliers list, always investigating new sources. ♦ ♣ Components must be TM approved. TM may recommend certain suppliers not be used due to bad experience. ♣ FC specify materials but not suppliers. ♦ ♣ Some suppliers avoided due to past performance, including confidentiality problems. Can be a problem that suppliers' facilities are not kept separate.	Prototyping for machining conducted by dedicated facility: automatic choice. Other prototype suppliers judged mainly on quality performance (supplier inspection report). FC received RFQ from TM and submitted a bid: formal process. ♣ TM issues guidelines ♣ Majority existing suppliers: gives mutual understanding of needs and requirements: expensive to switch supplier ♣ No problems in connection with suppliers having other customers: only issue is available capacity ♠ Limited specification by FC of sub-suppliers	Global roles of FC staff: aim to co-ordinate / allocate business across sites. ♣ Very close personal ties between FC Europe and TM partly because it used to be part of TM. FC Europe staff always interfacing with TM, exploring new business. ♦ FC encourages its suppliers not to do business with ADC i.e. FC's main competitor, as it would compromise its IPR.
Timing	FC involved with TM at detail design. All FC suppliers involved at detail design or later. Designs relatively fixed at that stage. Some suppliers not involved as early as respondent would like, but tooling (cost) constraints. ♣ Concerned that if suppliers were to decide on production process they would do so according to own process tech. rather than optimum, standardised benchmark geared to suit other source: reason for delaying their involvement till spec. is set. ♣ Experience influences timing if problems are foreseen (advance). ♠ No influence of sub-suppliers' timing	Production suppliers involved after prototyping, after testing to ensure TM is happy with product. Awareness that this is late.	FC's suppliers involved after initial concept definition. FC does not have full visibility of TM internal specification process/limited FC involvement in developing spec. in this project/late (post-spec.) involvement with TM. ♠ ♣♦♥ Limited network effect on timing due to limited involvement of suppliers in design and development. No attempts to co-ordinate suppliers and no constraints.	♣ Very close personal ties between FC Europe and TM partly because it used to be part of TM. Hence involved prior to RFQ. FC UK involved after initial prototyping/specification.
Mobilising	FC absorb own development costs with TM. FC/TM may jointly purchase suppliers' tools, but respondents does not perceive risks are jointly shared with TM. Ground rules set out in terms and conditions, quality documents (incl. workmanship and quality control standards). Recent, controversial, change of reject parts policy: suppliers now charged automatically. Suppliers generally not difficult to motivate. ♣ Easier to motivate historical suppliers ♠ FC tries to influence sub-suppliers mobilisation e.g. re. delivery targets, contacting some directly (sometimes incl. TM). May also include problem solving.	Some mobilisation problems occasionally internally due to project clashes but team is well-motivated.	Limited awareness of sharing of development costs but FC do not charge TM for pure engineering costs. Expensive tooling costs of suppliers passed on to TM (part of contract). Believes FC-TM ground rules, procedures etc. are understood fairly well. Suppliers motivated by volume/value of potential business. FC use 'exit' strategy to mobilise suppliers e.g. threatening to use alternative source if problems of meeting time scales. ♣ Easier to mobilise existing suppliers due to existing relationship and understanding.	FC product portfolio approach (conscious?) to balancing development costs and rewards: no agreed margins with TM. Formalised TM document contained contact names, roles, output, milestones etc. - mutually agreed with FC. IPR mutual agreements with TM. ♣ Long term relationship with TM provides motivation ♥ Perception that risks are being pushed upstream.
Communicating	Extensive communication of specifications, incl. ratings of components, failure analysis, technical and risk analysis	Much communication but not entirely transparent with suppliers (re. nature of project)	Much communication with TM through conferences and emails. Extensive communication of policies,	FC's cost/margin information almost transparent to TM.

	etc.. FC provides performance info. to TM. ♦ Little quality info. is withheld from suppliers but communication on need-to-know basis with TM and suppliers. Suppliers not always able to identify which project info. is for (confidentiality). ♣ Historical suppliers may receive more informal information ♥ ♠ FC has conducted limited supplier satisfaction survey, obtaining feed-back on FC-supplier relationship (discussion of supplier newsletter but dropped). ♠ FC encouraged communication between 2 suppliers. ♠ Joint FC/TM supplier development activity to share ideas (seen as useful).	and TM (re. problems). Many weekly conference calls but a perception of too little face-to-face communication. TM perception that FC is poor at communicating, withholding information re. problems, but respondent does not think communication is so bad.	specifications etc.. High degree of formalisation e.g. minuting of meetings and decisions, performance measurement etc.. ♦ Fairly 'open book' communication with TM, but only relevant information: aware that TM has asked FC to be more open with problems. ♣ Respondent works across projects so not 100% dedicated to this project: believe TM understand. ♠ No attempts to co-ordinate communication with FC's suppliers	Believes internal and external communication is an FC problem. ♣ FC accused by TM of withholding information when problems occurred, delaying messages not to lose face .
Problem Solving	FC suppliers generally seen as good at and willing to resolve problems but less good at preventing them. Occasional TM supplier development activity focused on problem solving, involving also FC key suppliers. ♣ Perceptions of FC developed over time of being too re-active have influenced suppliers and TM's perception of FC, some rather badly). ♣ No problems agreeing root causes with suppliers on technical issues, more difficult on soft issues. ♣ Some customers have expressed concerns about FC being too dependent on TM and thus not giving other customers the same attention. ♠ Sub-supplies may be involved in solving hard problems	FC not very open with TM about project obstacles: prefer to keep details of minor problems to itself but aware TM disagrees. On-going supplier development activities.	FC experienced many re-design/specification problems which were discussed openly with TM. FC does not have full visibility of TM internal specification process/limited FC involvement in developing spec. in this project/late (post-spec.) involvement with TM. FC suppliers not involved in process. ♣ No path dependency ♣ Fairly 'open book' problem solving process with TM: aware that TM has asked FC to be more open with problems.	ECM may liase directly with FC Europe when problems escalate due to its close relationship with TM. ♣ FC accused by TM of withholding information when problems occurred, delaying messages. Linked to perceived level of FC system control.
Exchanging human resources	No HR exchange on this project, but used to have some with TM.	No HR exchange, may be confidentiality concerns and also concerns about effect on productivity.	No HR exchange on this project.	No actual HR exchange. Exceptionally happens when problems. TM residents in earlier projects, building up understanding of FC.
Synchronising	FC prefer to work with suppliers with degree of process tech. flexibility to be able to meet FC's standards. Much efforts allocated to communicating and aligning technology roadmaps and quality development plans with TM. More piece meal with suppliers (did presentation 4 years ago but not since). ♣ Most synchronisation in place ♣ Few network constraints on synchronising: past concerns about small group of suppliers being used by too many telecoms companies	FC produces own project plan for TM.	Project plans synchronised with suppliers. Respondents believes TM has full visibility of FC's road maps. Perception that TM is very concerned about risks of adopting and developing new filter technology, so need not to be too innovative. Difficult to know future technological direction of TM: many different perceptions within FC.	Overall Gantt chart shared with TM Regular meetings at which FC technology road maps are presented to TM. TM in turn presents market trends. ♦ TM careful not to divulge individual suppliers' road maps, protecting IPR. ♣ FC keeps procedures generic to avoid too many customer-specific procedures.

Appendix F Continued: Analysis and Interpretation of Inter-Company Perceptions of Collaboration Activities with Key Suppliers and Customer: Base Station Equipment Project

	TM Project Manager	ECM Operations Manager	AluComp Operations Director Project Engineer Engineering Manager	TP Plating Operations Manager
Respondent's role	Project Manager, based in TM Networks	Operations Manager, with company for 5 years having worked closely with FC as engineer.	Ops. Dir.: responsible for all manufacturing, engineering and quality. Project Engineer: works up front with FC engineers on project implementation	TP Plating a profit centre within FC i.e. 'semi-external supplier'. Respondent reports to FC GM. Based within FC. App 60 employees in TP Plating.
Uniting	TM Networks UK assumed control of project due to lack of capacity in Europe. Subsequently FC UK took over from FC Europe. ECM became involved to assist with sourcing, although TM Europe still influenced global sourcing decisions. FC Europe originally given general specification and invited to quote. ♣ History important as it provides price, delivery and design credibility. Sub-suppliers approval process conducted over time/mid 1990s. Way to avoid having dual source. ♣ ♦ Some suppliers are non-preferred due to past performance/experience. May have been too careless about sensitive information sharing with TM competitors. ♠ TM specifies in contracts that it is allowed to check sub-suppliers: must be TM approved but are not directly specified by TM.	Limited formal selection process of ECM suppliers–development/prototype orders are placed when parts are required. ♣ ECM's key suppliers are FC-specified. Specifications disseminated from TM. FC involved in discussions with TM to compile list of approved suppliers. ♣ ECM has long-term relationships with its a core team of suppliers and FC: costly to change suppliers once they have gone through approval process	FC's process is a formal selection process: AluComp responds to RFQ, delay in receiving message whether business is won. Limited design work until order is secured. ♣ AluComp chooses suppliers based on list of approved suppliers. New more competitive suppliers may occasionally be introduced. ♣ FC may influence AluComp's choice of tooling suppliers, insisting on lowest cost supplier.	TP Plating involved per default due to internal status, provided it has the capacity.
Timing	FC UK became involved during initial prototyping, FC Europe just after concept phase/pre-specification. FC became involved later than a 'partner' would have been (concept development). ♠ FC has power to decide on timing of its suppliers/no TM influence.	ECM became involved 2 months after initial concept, during detail engineering. ECM has asked to be involved earlier to influence design specification.	AluComp quotes but is not involved till after prototyping. Late involvement creates problems e.g. cost, quality and meeting deadlines. Tooling becomes expensive due to unnecessary modifications.	TP Plating involved at prototype stage but neither takes part in developing concept nor specification. Seen by respondent as too late as creates manufacturing problems that becomes difficult to resolve. ♣ The lack of experience of early supplier involvement within FC prevents it from implementing it.
Mobilising	Less risk and reward sharing with FC compared with TM partners where frame agreements exist. Partners receive a higher margin to cover development costs, FC less but in a grey area receiving a good margin to cover some costs. AF perception that FC is unwilling to develop new innovative technology to avoid risks/cost, TM having to pull design/technology developments: AF disappointed. TM perception of FC engineers being de-motivated as its management has signed up for difficult deadlines putting pressure on engineers. Managers always keen to show TM it is important customer, listen to improvement suggestions etc.. ♣ Many contracts exist between TM and FC which set precedent for new projects. ♠ TM influences new strategic sub-contractors sub-suppliers mobilisation but not anymore with FC.	Some costs and margins of ECM suppliers negotiated by FC (free-issued). A prototype agreement exists between ECM and FC which specifies support for development work. (incl. costs and margins). Ground rules very invisible to ECM. The high dependency of ECM on FC business serves as motivator but can be frustrating when lack of visibility. ECM seeks to mobilise its suppliers and sub-suppliers (when through distributor) by informing of plans etc., sometimes bringing in FC or TM to 'add weight'. ♥ ? Contract sees a split of business in two (dual source) which serves to mobilise ECM as FC can switch. ♥ Long term nature of relationship helps to mobilise ECM	FC pays for tooling and products. No long-term agreements (other than T&C) /no guaranteed minimum volumes (risk and rewards measures). AluComp used to get to see Gantt chart with responsibilities etc. FC drives AluComp very hard – bullying. Seen as de-motivating as indicates low respect. Also the uneven project management is de-motivating. ♣ AluComp has policy of not being over-dependent on any customers: motivated for all customers. ♣ Problems with FC disseminate to AluComp's suppliers: have to work hard to mobilise these.	As internal profit centre situation is different: TP Plating charge for its work but FC bears cost when subsequent problems. Rules not entirely clear at beginning. Emerged during introduction and design process. Motivation is given. ♣ Some rules were different on this project, in terms of expected quality being higher.
Communicating	TM wants very open communication e.g. open book	Orders and specifications are disseminated from FC	Large amount of drawings with little project	FC's information normally on need-to-know basis

	costing with key suppliers and partners who can retain confidentiality: FC one such trusted supplier. TM can issue guidelines for technology performance but would prefer to let FC decide, however, TM has had to specify too much to FC/pull design process. TM performs vendor assessment and audits, communicating problems. FC also seen as very re-active on relationship development: subject of TM discussions. ♣ ♦ Some suppliers are non-preferred due to past performance/experience. May have been too careless about sensitive information, using this to own advantage with TM competitors.	to ECM and thence its suppliers. Visibility of FC activity and technology is very low within ECM. No performance information received from FC re. development work but some for on-going production. ♣ Aware that FC often struggles to obtain forecasts from TM: problem disseminates. ♣ Low visibility is a historic issue ♠ ECM has attended supplier seminars at FC for learning new manufacturing techniques etc. (no such ECM organised activities)	information sent by FC to AluComp. Very limited product information from FC incl.. forecasts. Information often delayed. Performance feedback is rare from FC. AluComp communicates very openly with its tooling suppliers, incl. plans. ♦ Perception of very high confidentiality awareness in FC to maintain competitive edge: information always retained and AluComp not allowed to use FC products for promotional purposes.	but as semi-internal respondent is able to obtain information informally through personal relationships. Also part of FC senior management so is aware of more strategic/policy information than other suppliers, although limited project progress information. Communication of performance requirements not very clear; limited performance feedback: mostly when problems (informal). ♦ Little relevant information is with-held due to internal status.
Problem Solving	TM performs vendor assessment and audits, communicating problems, having identified important programme management, and risk (incl. for technology performance) problems within FC. Have had reviews to discuss and resort/supplier development. FC's suppliers have not been involved to a great extent so far in the project so have not been involved yet in problem solving.	Problem solving process focused on identifying root causes, however, FC often quick to assume that problem lies in ECM internal processes.	Problems (normally design related) apparently mutually resolved between AluComp and FC: FC often sends in personnel.	Informal brainstorming-type problem solving process: often FC's starting point is to blame TP Plating. ♣ Past practices can prevent attempts to change manufacturing processes
Exchanging human resources	TM has key suppliers'/partners' engineers working alongside its own in house.	ECM very local to FC so has not been deemed necessary to allocate staff – never been requested.	No HR integration between FC and AluComp. Relationship not close enough/very limited design involvement. Has never been requested. More close integration with AluComp suppliers (tooling).	HR integration is fairly strong due to semi-internal status – adjacent premises.
Synchronising	TM shares technology strategy details with key partners/suppliers and FC has been involved in technology development programmes. FC has been conducting presentation of its road maps for future technology at TM, trying to align with TM. TM shares general for what affects FC but not TM product strategy. FC shares more technology strategy details with its partners however. ♦ ♣ TM concerned that FC has relationships with its competitors so restricts its ability to become partner. TM's preference is max. 30-50 % TM business for strategic sub-contractors, more for partners where frame agreements are in place to prevent dependency problems/for mutual support. ♣ TM prefers to let FC develop its project plan to avoid FC paying lip service to TM deadlines: past on bad past experience.	ECM has little visibility of FC activities and plans – frustrating due to high dependency. ECM has run a training school with internal and FC staff concerning quality management etc., in attempt to adapt to FC	AluComp is asked to produce its own project plan but does not get to see FC's overall plan, although it knows it exists: seen as a one-way street. Very limited strategic alignment, no technology roadmap exchange. AluComp provides rolling plans to its suppliers and its suppliers synchronise with these. ♦ Perception of very high confidentiality awareness in FC to maintain competitive edge: information always retained and AluComp not allowed to use FC products for promotional purposes. ♥ Systems and procedures aligned with QS9000 requirements rather than specifically FC (industry wide)	Many short-term requirements rather than long-term view, although as part of FC senior management respondent is more involved in strategic planning than other suppliers.

Appendix F Continued: Analysis and Interpretation of Intra-Company Perceptions of Collaboration Activities with Key Suppliers and Customer: Asian Car Development Project

	Business Unit Director	Manufacturing Manager	Technical Manager/Leader	Project Manager/Leader
Respondent's role	Overall programme responsibility	To manage project from prototype to production/ramp up.	Manage technical aspects of project, incl. interface with prototype suppliers. Also managed manufacturing till project reached production phase. Link to VM R&D.	Responsible for interface with client/VM: link between manufacturing and technical side. Key role in setting up commercial arrangements.
Uniting	Re. production suppliers: AE conducted structured vendor selection process but several parties 'vetoed' process: eventually largely unstructured and somewhat political. Re. prototype suppliers: only two and existing suppliers to either AE or sister company. Similar process of. uniting of VM with AE. ♣ Established relationship with one prototype supplier (Prototype Supplier 1) – easy decision. ♣ JV's suppliers existing, often on-site, suppliers to the Asian company (no formal assessment); AE no history with these even if it had previously been involved with their Western JV partners ♣ Would have avoided many suppliers not seen technically competent or geographically unsuitable. Ultimate choice was not AE's but Asian manufacturer (in JV). VM largely trusting AE to decide. ♦ Some suppliers deemed unsuitable because of their existing relationships with VM's competitors: concern re. loss of knowledge of technology to competitor ♥ Other prototype supplier (Prototype Supplier 2) a current supplier to AE Motor Sport sister company. ♠ AE wanted to specify sub-suppliers, especially for safety-critical parts. Would normally specify more – less here due to low cost nature of vehicle/market. Specified parts through tight design specification and thus limited no. of suppliers able to meet requirements.	Re. production suppliers: AE attempted to conduct a formal structured vendor selection process on behalf of VM but Asian party changed the selection somewhat due to largely political reasons. Re. uniting with the customer VM approached AE. ♣ Most of the AE manufacturing team is from an OEM background and therefore well connected with technically competent suppliers. But ended up with very few existing suppliers due to lack of VM's infrastructure in Asia thus no list of preferred suppliers. ♣ One prototype supplier chosen due to existing relationship with AE ♣ VM (USA) and AE had worked extensively together previously, particularly in niche market/new technology. ♣ VM Purchasing intervened late in project and specified certain key suppliers. ♣ Did not avoid any suppliers: sought global suppliers with presence in Asia ♣ VM did not seek to dictate selection process, but would discuss with AE (limited guidance from VM) ♠ AE tried to make recommendations, although changed by VM; developed a framework/specification but sub-contracting decisions mainly left to suppliers. AE avoided specifying actual sub-suppliers as it could later get blamed for having imposed choice.	♣ Prototype suppliers primarily chosen because AE, or people on project, have worked with them before. Trust they can do the work, way to reduce risk: investigated alternatives but decided on low-risk option ♣ ♦ Sticking to existing suppliers provides a way of avoiding risky/non-trust-worthy suppliers ♠ AE asked prototype suppliers to dual source due to time scale and scale of project, and to use their existing suppliers (specified): spreading risk. ♠ Prototype suppliers' key material suppliers were jointly specified by VM R&D and AE	♣ Having decided to enter the Asian market, VM allocated project to Far East subsidiary. AE had historical relationship with Holden through racing, AE owning Holden Special Vehicles. ♣ AE would like production suppliers to have long-term preferred suppliers in place. ♥ VM used Holden as conduit to AE: a European partner.
Timing	Production suppliers became involved after prototyping (incl. Crash testing): seen as late. ♣ Prototype suppliers were involved from the start (their job) but limited opportunities for their particular capabilities due to nature of vehicle (i.e. simple). ♠ AE did not try to influence timing of sub-suppliers. Barriers were: distance and capability level (incl. language) of upstream positioned suppliers. Hence used largely standard parts instead of customised.	Suppliers asked to tender after AE had produced specifications: vendor selection process 6 months later where AE made final decisions and sent letters of intent to chosen suppliers. Prototype suppliers became involved during concept development, immediately after AE ♣ AE did not seek to delay involvement of any suppliers: wanted them involved asap. But they were still involved very late due to problems arranging the JV ♠ Did not try to influence timing of sub-suppliers' involvement	Prototype suppliers involved from day one: involved in detail design and feasibility study. AE involved from day one with VM. ♠ AE encouraged prototype suppliers' involvement with their key suppliers	Production suppliers involved late ♣ This was due to JV arrangement taking time to be completed. AE involved 6 months before VM started to allocate a project team itself. ♣ This was because VM never really believed project would go beyond concept development. ADC involved during concept development, producing a (non-engineered) show car.
Mobilising	Development costs part of agreement: fixed price contract, including prototyping, tooling etc. Production suppliers generally charged for prototype parts but managed by VM. Ground rules constantly changing, including programme strategy and contractual agreement. People involved have changed several times (on customer side). AE has remained stable however.	Limited risk and benefit sharing: both production and prototype suppliers have been paid for a set scope of work only, incl. AE: payment plan agreed based on 3-month targets. ♣ Respondent believes ground rules and overall VM management of the project has been poor, not least due to problems of arranging JV.	Risk was limited as only innovation was in the high volume application of the material: material itself known. Prototype suppliers take limited risk as they are paid for what they do; knew they would not be involved in production, although early on that was less clear so acted as carrot for some suppliers.	Original contract with VM did not include all aspects of vehicle engineering as project relied on suitable donor vehicle being in existence. This additional task had to be undertaken by AE.

	Tried hard to formulate objectives throughout programme; developed programme management plan together with rep. from VM, trying to allocate responsibilities, but VM effectively refused to agree it. VM very reluctant to play by any ground rules, particularly roles and responsibilities. AE experienced difficulties motivating prototype suppliers due to amount of changes – particularly no. of engine (and subsequent re-engineering) changes. Made it difficult also to motivate people internally. ♣ Mobilisation problem not least caused by difficulties in setting up the JV, adding delays, information constraints etc. ♠ Did not try to influence motivation of sub-suppliers due to high degree of carry-over in design and parts.	VM's objectives in terms of vehicle concept was clear, but logistics and infrastructure unclear. AE's suppliers motivated due to scope of project (volume + new market) but many concerns re. cultural problems, payment and shipping concerns. ♠ AE did not try to influence motivation of sub-suppliers	Ground rules spelled out for prototype suppliers in their purchase orders.	
Communicating	With VM, design ideas and concepts were communicated through manager placed on site within AE. VM reluctant to commit to any policies and procedures: limited communication. Only anecdotal communication on performance from VM. AE report weekly on programme performance. VM unwilling to listen to AE. Two prototype suppliers closely involved in design reviews etc. and on site frequently. Received both formal and informal feedback. Production suppliers had limited communication due to their late involvement: limited influence on design. Also, language barrier as these are SMEs. ♦ Did not withhold any technical information. Asked by VM to keep some aspects confidential with JV partners. General policy has been 'open book' within key relationships, but high degree of confidentiality out-with. Believes VM would have kept more details confidential, but AE wanted it to be open. JV arrangement problems constrained AE receiving knowledge re. manufacture. ♣ No problem sharing info. with prototype suppliers. Very limited discussion with production suppliers re. manufacturing methods, materials etc.. ♥ Encouraged communication between two prototype suppliers but could not do the same with production suppliers, e.g., inform them at forums, due to set up.	With VM, communication of design ideas and concepts took place via styling reviews/clinics: AE producing concepts to be reviewed by VM. Suppliers had limited involvement in styling and concept development: high degree of confidentiality out-with VM-AE. But Asian production suppliers very keen to learn as they are not used to innovating vehicles. Supplier selection was communicated via meetings with VM (when suppliers presenting/tendering). Very frequent conference calls with VM and much electronic communication + meetings: extensive communication. Language and cultural barrier ♦ High degree of confidentiality surrounded project: suppliers informed on need to know basis and confidentiality agreements. Core technology is very closely guarded: only AE and VM R&D know the details. ♠ AE only communicated with direct suppliers: sub-suppliers no need to know/AE rely on direct suppliers to disseminate information	Much communication with VM evolved around review meetings. A range of electronic and non-electronic/face-to-face means of communication used. AE has facility for electronic design reviews: cross-functional and cross-company. Meetings take place where emphasis of work is. AE received little documentation, work procedures etc. from VM; asked AE to propose this. Performance communication with suppliers fairly rudimentary; no open book negotiation with prototype suppliers. ♦ No information withheld from prototype suppliers but informed on a need to know basis. Only companies that absolutely must know are informed: limits dissipation of knowledge e.g. if people leave company ♠ Two prototype suppliers automatically on team email circulation list, being informed about decisions, questions, issues.	♣ ♥ VM's failed attempt to use its strategic alliance with Other European VM to allow AE to use engine, gearbox and suspension from their partner in Asia, meant that AE had limited information. AE then communicated direct with Other European VM who provided much knowledge. ♦ AE not overly concerned about losing knowledge in this project as the sensitive part is VM IPR, not AE's. ♥ AE had discussions with Other Japanese VM and Other European VM in its search for suitable donor vehicles, both companies being VM alliance partners in the Far East.
Problem Solving	A normal process where everybody gets together to identify root causes of problems. With VM, technical problem solving was AE's responsibility: would use the VM resident for guidance. VM often reluctant to listen to AE's advice re. potential problems. Few problems with suppliers. Prototype suppliers offered AE advice when problems occurred. ♣ Many problems occurred due to high frequency of engineering changes. ♣ Problems agreeing root causes of problems with VM R&D as they are researchers with limited interest in production. ♣ Many problems caused by inexperience of working with the Asian.	AE however has a very structured approach to problem solving seen as more holistic and non-blaming based; operates a central database collecting all problems encountered: meetings with suppliers to resolve problems. VM seen as having a unstructured approach to problem solving. AE sees the problem solving as its responsibility but will involve VM if necessary. ♣ Problem solving process not dependent on past experience, but many problems arose because project contained so many unknown factors hence difficult to identify root causes: no benchmarks.	A very structured and cross-functional process within AE, involving suppliers if necessary. Design problems resolved at weekly design review held in virtual reality centre. Problems are identified, tracked in electronic system, and person allocated to resort problem. AE closely involved in problem solving in Asia, helping to prepare for production. ♣ Root causes jointly agreed: a no-blame culture.	
Exchanging human	With VM, design ideas and concepts were communicated through VM vehicle integration manager placed on site	AE's Manufacturing Group team of 10 engineers constantly travels between AE in the UK and VM	Much interaction and exchange of engineers and managers across several companies:	

human resources	within AE – as keeper of the faith/concept. Two prototype suppliers closely involved and on site app. two days a week but not as guest engineers. More closely involved than other AE projects. AE people often in Asia but only visiting. Not seen as critical due to simplicity of engineering task for production suppliers (but complex supply task).	(Asia): office at the customer's site. 'Heavy' support from many direct production suppliers, sending over people for e.g. 1-2 month e.g. for training at AE. Also involved Asian part of the JV/customer. Also AE resident engineer in Asia. Respondent believes HR exchange was quite extensive. ♦ ♣ AE did not avoid allocating staff from anyone	VM had engineer based at AE full time and AE has engineers based at prototype supplier to review progress and assist. Two designers from ADC worked at AE's for 6 months to understand design processes. People from AIC at AE and both prototype suppliers during prototyping, to learn. But no reps. From prototype suppliers based at AE. ♦ Project areas are restricted access: key project personnel entry only ♣ Exchange of people not a regular process for AE ♠ 2 engineers from suppliers to prototype suppliers on site helping out	
Synchronising	AE not interested in aligning its technologies with other companies, other than trying to liase with VM R&D departments. Respondent very disappointed by lack of synchronisation with VM who would/will not share e.g. programme timing with production suppliers. Reason: ♦ VM very concerned about lack of ability in Asia to maintain secret: concerned that knowledge of materials (the key tech.) will dissipate to competitors via suppliers ♣ Mutual synchronising difficult due to late involvement of all JV partners and production suppliers. AE asked them to synchronise if they could/would ♣ Not a problem to synchronise with companies being involved with other companies as that is a cornerstone of the organisation: to be flexible and adapt.	Overall project plan developed jointly by VM and AE: suppliers asked to fall in line with that. The project leads/precedes the development of the technology i.e. the application ♣ Adaptations not in place from previous interaction as project has so many different/new elements	Some synchronisation by prototype suppliers but relatively limited as their involvement was 'grey box'. Other suppliers black box and thus needed to synchronise more closely. AE has recently announced a strategic liaison with other engineering company, seeking to jointly develop new technology: a new role for AE	AE try to keep its systems and language generic, e.g. limiting jargon, so that they are more easily transferable across customer relationships (♣).

Appendix F Continued: Analysis and Interpretation of Inter-Company Perceptions of Collaboration Activities with Key Suppliers and Customer: Asian Car Project

	VM	Prototype Supplier 1	Prototype Supplier 2
Respondent's role	Director Product and manufacturing. Overall technical responsibility, incl. Manufacturing. Reports to vehicle line executive ('Programme Director')	Engineering Manager Project Engineer	Works Director: manages customer relationships: sales and technical role.
Uniting	No competitive bidding process. ♦ Confidentiality a major issue in project due to level of new technology: VM assessed which other companies potential suppliers worked with; some concerns re. particular suppliers. ♠ VM discussed supplier choices with AE and tried to encourage use of certain suppliers but no requirement/specifications: mutual decision	Joined meeting with other prototype supplier to quote for job. ♣ Involved through having worked on past projects, building up reputation. Have also worked with most of the suppliers before ♣ Did not avoid any suppliers ♠ Did not try to co-ordinate any suppliers: limited choice due to tech. spec.	♣ Became involved through previous project: was invited to quote. Had not worked with most of he suppliers before. ♣ ♥ VM specified materials as this was part of the key technology from their R&D department. Some specified through AE. Did not avoid any suppliers. ♠ Did not attempt to co-ordinate suppliers
Timing	AE became involved in programme to complete the final feasibility study i.e. immediately after concept development. VM R&D had been working on basic technology for maybe 4-5 years before then. ♠ VM did not try to influence at what stage AE was to involve its suppliers, but the programme timing plan made this clear.	Prototype Supplier 1 became involved for concept development/detailed design: took part in final CAD design process and produced first prototype prototype. Less of an issue/collaboration with Prototype Supplier 1's suppliers as these simply produce according to spec. Pressure on timing due to tight time scale: no network effects.	Became involved simultaneously with Prototype Supplier 1: concept development/basis design. Suppliers became involved once Prototype Supplier 2 had secured the order i.e. a gap: equipment suppliers first, then material suppliers. No network effects.
Mobilising	Respondent tried to work hard on establishing ground rules and roles and responsibilities. He joined project later so re-opened the original contract to clarify issues. Level of specification was relatively high hence some uncertainty/flexibility built into programme management. ♠ Did not try to delegate roles and responsibility at detailed level: individuals left to identify how to progress themselves. But encouraged suppliers to ensure the goals were clear (not dictating) ♣ Only effect on motivation was need to feel each other out/getting to know each other.	Limited relevance of risk/cost sharing as Prototype Supplier 1 simply receives payment upon completion of job. AE outlined ground rules in RFQ/terms and conditions. Prototype Supplier 1 responded to those. No motivation problems: no network effects.	Limited relevance of risk/cost sharing as Prototype Supplier 2 simply receives payment upon completion of job. However, Prototype Supplier 2 put in more work to complete the job than was quoted in the expectation that it would be involved also in production (for tooling). Did not happen so disappointed. No motivation problems of Prototype Supplier 2 or suppliers as expectation was to obtain part in production (some, incl. Prototype Supplier 2, were informed they would have a part in production but did not accomplish it – suspected VM decision to source from Asia). Limited ground rules in place. ♠ Prototype Supplier 2 did not attempt to influence how its supplies mobilised their suppliers
Communicating	Communication very open amongst main parties, language and cultural problems with Asian parties. High degree of electronic communication in this project. Performance feed-back on continuous basis ♦ ♠ VM insisted that AE obtain confidentiality agreements from its suppliers (even providing the forms). ♦ Asian parties would withhold information – cultural trait. VM has only withheld information concerning key material technology details: high degree of transparency otherwise (incl. cost details). ♣ Open sharing of information a new way of working for AE: initial trust problems between VM and AE due to past problems between engineering suppliers and VMs. Respondent made effort to build up trust from beginning. ♠ Tried to encourage communication amongst 2 prototype suppliers and their links with JV as they had a special role	Meetings and electronic CAD data transfer. No official performance feed-back from AE and to Prototype Supplier 1's suppliers. ♦ Communication restricted out-with parties having signed confidentiality agreements. Other suppliers do not even know who end/indirect customers are. ♦ Confidentiality specified by AE but standard practice.	Much communication via email and meetings. Terms and conditions on RFQ. No formal performance assessments. ♦ Suppliers not informed about who end customer/VM is (confidentiality agreements in place, but communication with main partners very open, although suspected that AE had with-held knowledge of Prototype Supplier 2 not to become involved in production to maintain carrot. ♣ No effect of history on communication
Problem Solving	Problem solving a two-way process between VM and AE: a partnership. Respondent worked hard to ensure no blaming to place: development of trust. ♣ Process initially inhibited by lack of existing relationship between VM and AE: lack of mutual understanding. ♣ Process inhibited by AE being used to working in a different way: keeping things internally rather than involving external partner in process.	Various design faults or failures. A two way process: ultimately AE's responsibility but Prototype Supplier 1 tries to produce to meet the spec. ♣ Problem solving ability grows with experience ♣ Process may be hindered by individuals working across different projects hence being difficult to contact.	Some problems with lead times from suppliers: Prototype Supplier 2 would chase deliveries or seek out alternatives. Meetings to discuss design/manufacture problems with AE. Focus on cause of problem rather than blame. ♣ No effect of history on problem solving process. ♥ VM involved in some problem solving, sometimes together with AE

Exchanging human resources	VM and Eltra residents at AE during early part of project; 4-5 AE residents in Asia (initially resisted): improved communication. Much travelling of people between UK and Asia for long visits. ♠ (minor ♣: for AE) VM strongly encouraged residents in Asia but did not make it a requirement ♣ Reason for need for residents: AE's lack of experience in working overseas	AE had office at Prototype Supplier 1 for project. ♠ ♥ Extensive HR exchange of Asian party sending over people for training	AE engineers had office at Prototype Supplier 2 (one manufacturing engineer full time) to learn as much as possible about the manufacturing process: unique situation. No other exchange. ♣ Not affected by history of relationship: purely due to nature of job.
Synchronising	Overall programme management/timing plan mutually agreed amongst VM and AE – input also from e.g. prototype suppliers: a combination of VM and AE method of vehicle development. No explicit discussion of alignment of long-term technology strategy plans between AE and VM. ♣ Project team not required to use existing VM processes: freedom to choose suitable processes	Prototype Supplier 1 had to synchronise by adapting to AE's project plan (timings). No alignment of technology plans: works project by project. ♣ (Previous experience with customers helps to assess whether timings are realistic) ♣ Only problem for Prototype Supplier 1 may be the small quantity it is able to order as large suppliers of e.g. steel may have far more important customers	Prototype Supplier 2 supplied a timing plan, Gantt chart: AE had some input into timings but project was very process driven: set timings. No consideration of long term alignment of technology development plans.

Appendix F Continued: Analysis and Interpretation of Intra-and Inter-Company Perceptions of Collaboration Activities with Key Suppliers and Customer: Interception Gateway Project

	Supply Chain Manager, NetCom (UK)	Project Manager, NetCom (US)	Sales & Marketing Director, Securicom
Respondent's role	Product management responsibility. Joined FC at start of project.		Customer account responsibility. Limited involvement in supplier relationships.
Uniting	2 main suppliers in the (niche) market invited to tender: identified through market analysis. Compliance with standards and global presence critical. ♣ Securicom was natural choice as already supplying for 2G (existing contract): natural evolution and hence reduced development costs. ♣ One supplier not invited to tender due to lack of global presence. Suppliers' other customer relationships not a problem: offerings have to comply with different customer technologies/complementarity. ♠ No attempts to specify sub-suppliers/no approved parts list: seen as Securicom's responsibility and FC does not have the influence/leverage in this market. Also little hardware to specify.	Securicom underwent FC's vendor management process, including formal supplier selection and evaluation. ♣ ♥ Existing relationship worked against Securicom, as experience had not been entirely satisfactory for FC. But the 2 suppliers evaluated were both previous suppliers to FC hence enabled both to be pre-selected. ♣ No other network constraints ♠ No FC attempts to specify sub-suppliers.	Interactive process: FC considered whether to develop in-house but during discussions with Securicom FC decided to sub-contract and invite to tender. Securicom underwent a formal tender, competed with another company, and won contract. ♣ History of relationship with FC was important as this gave FC the confidence that Securicom could deliver as promised. ♣ Minor effect of existing nature of relationship with FC on Securicom's decision to bid for contract ♣ ♠ ♥ No attempts by FC to specify or approve Securicom's suppliers, although FC once suggested an alternative supplier unknown to Securicom. Complex software product architecture restricts usefulness of this.
Timing	Specification internally produced by FC. Securicom became involved after specification: time implication (negative). FC has culture of producing specs. in-house. ♣ No network constraints on timing ♠ No attempts to influence timing	Timing considered early (given that Securicom's offering is seen as standard). Securicom did not have input to specification but was invited to quote immediately afterwards. Timing seen as standard within FC. ♣ No path dependency effect on timing ♠ Sub-supplier timing left to Securicom	FC developed specification in-house and Securicom prepared document in response proposing adjustments: Securicom involved after spec.
Mobilising	Formal contract between FC and Securicom: FC owns IPR: not shared. Securicom receives payment upon completion of contract. Responsibilities set out for specific objectives through programme plan (Gantt charts): shared with Securicom but have been subject to debate. ♣ No initial problems motivating Securicom but during final project stage its priority seemed to shift to generate business with other customers.	No sharing of costs: Securicom paid for job quoted: 'blanket cost'. Milestones were mutually agreed, including responsibilities. FC experienced no problems inducing Securicom to commit although meeting commitments were a problem.	Fixed contract establishes costs, terms & conditions (incl. ground rules etc.). Overspending becomes Securicom's problem. Respondent had problems persuading his own company to commit to contract as they were unsure of the future potential of the project. ♣ Industry/FC standards for projects: Securicom aware from past involvement. ♣ Indications that other more important customer relationships may influence motivation to commit to project: respondent reluctant to admit this influenced Securicom's commitment to FC
Communicating	Initial design information communicated through RFQ and Securicom's proposal. Weekly meetings to review progress. ♣ Policy and procedure information in place from existing contract ♦ No information withheld from Securicom: NDAs, but less relevant for this relationship. FC trust suppliers to respect confidentiality. ♠ FC does not attempt to influence Securicom's supplier communication	Mixture of formal written documents and oral presentations and meetings. Formal project performance feedback exchanged once: both directions from parties' quality departments. ♣ Securicom perceived as hesitant to share information openly. FC seen as much more open. Respondent believes Securicom re-allocated resources to other projects ♣ Believes deliverables were very clearly defined in this project, based on lessons from previous projects where deliverables were unclear. ♠ ♥ No communication with Securicom's suppliers.	Extensive communication between technical FC and Securicom staff: much is email or conference call-based due to geographical distance. Vendor assessment information exchanged. No open book negotiation. Cultural differences affect timing and directness of communication. ♦ Does not believe any significant information was withheld, except occasional schedule information. NDA and trust with FC means 3rd party relationships do not affect extent of communication. Tacit nature of knowledge makes it difficult to transfer anyway.
Problem Solving	FC process focused on identifying root causes: resolved through communication but escalation proved necessary in some instances. Problem to get Securicom to recognise existence of problem and agree on cause of problem. Securicom tried to resolve problems internally itself and did not inform FC of problems till very late.	Many problems for Securicom meeting milestones and delivery dates. Also problems during testing re. product functionality: Securicom made required changes to resolve problems. Seen as unwilling to customise product.	Problems meeting delivery targets. Problems resolved through escalation process and reaching eventual agreement. Focus on solving problems rather than blaming. ♣ ♣♦♠ No network effects
Exchanging human resources	Securicom engineers have worked on site in FC on project – not as extensive as on other FC projects: days or weeks (as project is not regarded as key within FC).	Only HR exchange were Securicom engineers on site for testing (weeks): less than on other projects due to limited development work required	Securicom staff on site at FC during installation and testing: a few weeks at a time. ♦ ♣♦♠ No network effects: NDAs and trust ensure confidentiality
Synchronising	FC and Securicom both very industry standards-driven: need to align developments with general industry developments and standards. ♣ Programme plan (Gantt charts) shared with Securicom but have been subject to debate. Also wish to align Securicom road map with FC but Securicom claims it has no road maps: source of frustration within FC	FC insisted that Securicom had to agree to using FC processes, rather than its own. Securicom used to provide road maps but has not shown these recently despite FC requests. FC provides Securicom with projected sales info. ♣ Insistence on using FC processes based on previous bad experience	Timings, deadlines, milestones etc. synchronised. Securicom seeks to satisfy FC's needs, also watching FC's long-term development. ♣ Respondent occasionally needs to persuade his internal management of FC's importance and the need to synchronise with its systems that may be different from those of other customers.

Appendix G Part A: Analysis Matrices Used for Inter-Case Analysis: Network as Constraint on Collaboration Activities

	Base Station Equipment Project	Interception Gateway Project	Asian Car Project	Fuel Tank Project
Uniting: Dependency effects	• Administrative dependency: indirect sub-supplier specification through customer parts approval list • Path dependency: established suppliers on approval list– costly qualification process to add new suppliers to list.	• Path dependency: 2G collaboration history partly constrained FC's choice of key supplier • 2G collaboration history partly enabled FC's choice of key supplier	• Administrative dependency through limited 'consensus-focused' intervention in supplier selection by customer • Positive path dependency: History with prototype suppliers: involved per default to reduce risk.	• Administrative dependency through customer intervention in sub-supplier specification • Path dependency: FC suppliers need track record to become selected i.e. relationships with other customers
Uniting: Dissipation of knowledge & technology effects	Approval list excluded suppliers failing to respect confidentiality	• No apparent effects	• Some suppliers deliberately avoided due inter-connected customer-supplier relationships and associated fears of risk of loss of knowledge to competitors	• No apparent effects
Timing: Dependency effects	• Path dependency: lack of experience of early supplier involvement prevents practice • Close historical link between customer Europe and FC Europe enabled early involvement (positive path dependency)	• Technological dependency: FC produced specification in-house due to internal competence (afterwards recognised supplier's specification competence is stronger)	• Late involvement of several parties due to JV set up problems, notably production suppliers: administrative dependency	• No apparent effects but previous experience had shown importance of early supplier involvement (positive path dependency)
Timing: Dissipation of knowledge & technology effects	No apparent effects	• No apparent effects	• No apparent effects	• No apparent effects
Mobilising: Dependency effects	• Logistical dependency: customer frame agreements with highly dependent suppliers • FC problems transfer across relationships and cause chain of mobilisation problems • Past involvement enabled supplier motivation (positive path dependency)	• Logistical/administrative dependency: key supplier struggling to commit resources due to other customers	• Frequency of changes in JV set up & ground rules: administrative dependency +frequent engine (and related) changes: technological dependency: caused frustration/mobilisation problems for FC	• Administrative dependency: through Customer intervention in sub-supplier specification and management caused mobilisation problems
Mobilising: Dissipation of knowledge & technology effects	No apparent effects	• No apparent effects	• No apparent effects	• No apparent effects
Communicating: Dependency effects	• Path dependency: suppliers failing to respect confidentiality non-preferred. But historical suppliers receive more information (positive)	• No apparent effects	• FC experience with other vehicle manufacturers restricted communication with customer (path dependence). • Weak customer alliance relations and JV problems constrained extent of communication: knowledge, technical, and admin dependencies.	• Administrative/technological dependency: FC circumvented in sub-supplier-Customer communication re. design changes, terms & conditions, and cost/margin • Positive path dependency: previous experience had shown importance of openness of communication..
Communicating: Dissipation of knowledge & technology effects	• Information re. project problems withheld from customer: FC confidentiality culture	• No confidentiality concerns: managed through NDAs and trust.	• Confidentiality concerns restricted communication: need-to-know basis (open within select relationships).	• Key supplier withheld design information from FC to avoid loss of technology.

Exchanging Human Resources: Dependency effects	• No apparent effects	• No apparent effects	• Few network effects: only FC's lack of experience in HR exchange affected its willingness to allocate residents to project (lack of path dependency).	• No apparent effects (limited respondent knowledge of activity)
Exchanging Human Resources: Dissipation of knowledge & technology effects	• Possibly no HR exchange due to confidentiality concerns	• No confidentiality concerns: managed through NDAs and trust.	• No apparent effects	• No apparent effects (limited respondent knowledge of activity)
Synchronising: Dependency effects	• Customer reluctant to share road maps with FC: partly due to FC having other customer relationships: administrative and technological dependency • Positive path dependency: only example related to synchronisations being in place from previous projects	• Key supplier reluctant to share road maps with FC: possibly due to different customer requirements: administrative and technological dependency • Technological dependency: need to comply with 3G standards.	• Delay in JV arrangement caused late synchronisation with production suppliers: admin dependency • FC coping with different customer systems: administrative dependency • No effect of history on synchronising, although history an enabler in judging realism of project plans e.g. milestones (positive path dependency).	• Administrative/technological dependency: FC lacked control over its own module design and manufacturing due to Customer intervention in choice of sub-supplier and technology • Positive path dependency: previous experience enabled process
Synchronising: Dissipation of knowledge & technology effects	• No apparent effects	• No apparent effects	• Customer unwillingness to synchronise with production suppliers (confidentiality concerns/risk of loss of knowledge)	• No apparent effects
Problem Solving/knowledge exchange[136] Dependency effects	• Path dependency: people being change averse • Perceived administrative dependency problem: FC being too dependent on customer	• No apparent effects	• Lack of history/existing relationship betwee And customer: no initial mutual understanding • Lack of technological path complicated root Analysis • Technological dependency: problems agreei Of technical problems with customer R&D • Administrative dependency: balancing diffe Projects	• Similar to communicating: FC circumvented in sub-supplier-customer knowledge exchange: Administrative/technological dependency
Problem Solving/knowledge exchange: Dissipation of knowledge & technology effects	• No apparent effects	• No apparent effects	• No apparent effects	• Examples of perceived loss of technology from FC to Customer dual source

[136] Knowledge exchange was replaced with problem solving after EuroPart case. EuroPart data in this row refers to knowledge exchange.

Appendix G Part B: Analysis Matrices Used For Inter-Case Analysis: Network as Enabler of Collaboration Activities

	Base Station Equipment Project	Interception Gateway Project	Asian Car Project	Fuel Tank Project
Uniting: Network as conduit	FC consulted customer re. its assessment of FC suppliers	No examples/cases	FC involved through customer subsidiary in Far East	One supplier acting as a sourcing function to Japanese 3rd tier suppliers
Uniting: Network co-ordination	Indirect (parts) specification by FC in conjunction with TM	No attempt by FC to specify sub-suppliers	FC asked prototype suppliers to dual source to limit risk Indirect FC supplier specification for safety critical parts (agreed with customer).	No examples/cases
Timing: Network as conduit	No examples/cases	No examples/cases	No examples/cases	No examples/cases
Timing: Network co-ordination	No examples/cases	No attempt by FC to influence timing of sub-suppliers	Limited attempts by FC/customer to influence timing of sub-supplier involvement	No attempts by FC to influence timing of sub-suppliers
Mobilising: Network as conduit	FC dual sourcing mobilised supplier performance	No examples/cases	Few significant effects	FC relationships with JV partners increased its dedication to project
Mobilising: Network co-ordination	FC negotiating with indirect suppliers FC drove sub-supplier delivery targets in conjunction with customer	No examples/cases	Customer encouraged suppliers to ensure clarity of goals	Few significant effects: no attempts by FC to influence mobilisation of sub-suppliers
Communicating: Network as conduit	No examples/cases	No examples/cases	FC networked with customer's alliance partners without customer's assistance, seeking technical information and solutions.	Networking is way to obtain informal information e.g. re. launch delays
Communicating: Network co-ordination	Two FC suppliers asked to communicate to resolve delivery problem	No examples/cases	FC encouraged communication between two prototype suppliers	No examples/cases
Exchanging HR: Network as conduit	No examples/cases	No examples/cases	No examples/cases	No apparent effects (limited respondent knowledge of activity)
Exchanging HR: Network co-ordination	No examples/cases	No examples/cases	HR exchange across two supply chains prototype and production suppliers Prototype sub-suppliers offered assistance at FC	No apparent effects (limited respondent knowledge of activity)
Synchronising: Network as conduit	No examples/cases	No examples/cases	No examples/cases	No examples/cases
Synchronising: Network co-ordination	No examples/cases	No examples/cases	No examples/cases	No examples/cases
Problem Solving[137]: Network as conduit	No examples/cases	No examples/cases	No examples/cases	Networking is way to obtain informal information e.g. re. design changes Learning through (customer-FC-other customers) triad
Problem solving: Network co-ordination	Few effects: involvement of FC sub-supplier in resolving complex problems	No examples/cases	Few effects: assembly of 'indirect' actors to resolve problems	No examples/cases

137 Knowledge exchange was replaced with problem solving after EuroPart case. EuroPart data in this row refers to knowledge exchange.

Appendix H: Respondents Involved in the Four Case Studies

	Fuel Tank Development Project	Asian Car Development Project	Base Station Equipment Development Project	Interception Gateway Development Project
Respondents	Focal Firm Interviews: - General Manager (main contact) - Production Manager (Project Engineer during fuel tank project) - Project Engineering Manager - Commercial Co-ordinator - Quality Manager - Purchasing Manager - Manufacturing Manager External Interviews: - EP-JV1: Programme Manager - J-Car (customer): New Product Engineer - J-Car Commerce (supplier): Sales Team Leader - J-MasterPart (supplier): Sales Manager + Sales Executive - ToolMaster (supplier): Works Director + Managing Director	Focal Firm Interviews: - Business Unit Director (main contact): interviewed twice - Managing Director - Manufacturing Director - Manufacturing Manager - Technical Manager - Project Manager External Interviews: - Asian-VM JV (customer): Director Product and Manufacturing - Prototype supplier 1: Engineering Manager + Project Engineer - Prototype supplier 2: Works Director	Focal Firm Interviews: - Global Programmes Director (main contact) - Programme Director - Programme Manager - Programme Administrator - Engineering Director - Group Quality Manager - Sales Manager - Purchasing Manager External Interviews: - TM (customer): Project Manager - ECM (supplier): Operations Manager - AluComp (supplier): Operations Director, Engineering Manager & Project Engineer - TP Plating (supplier): Operations Manager	Focal Firm Interviews: - Supply Chain Manager (main contact): interviewed 3 times - Project Manager External Interviews: - Securicom (supplier): Sales & Marketing Director